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IRON AND STEEL ENGINEER

SEPTEMBER • 1941

VOL. XVIII NO. IX

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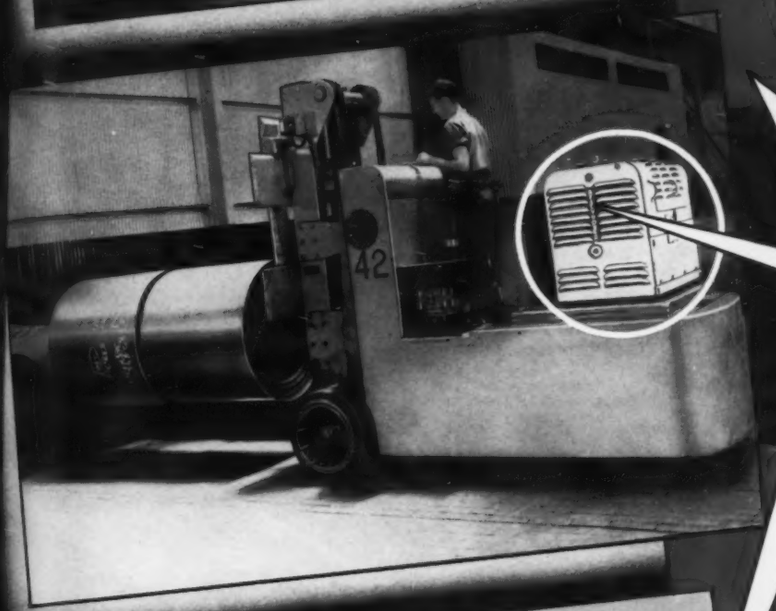

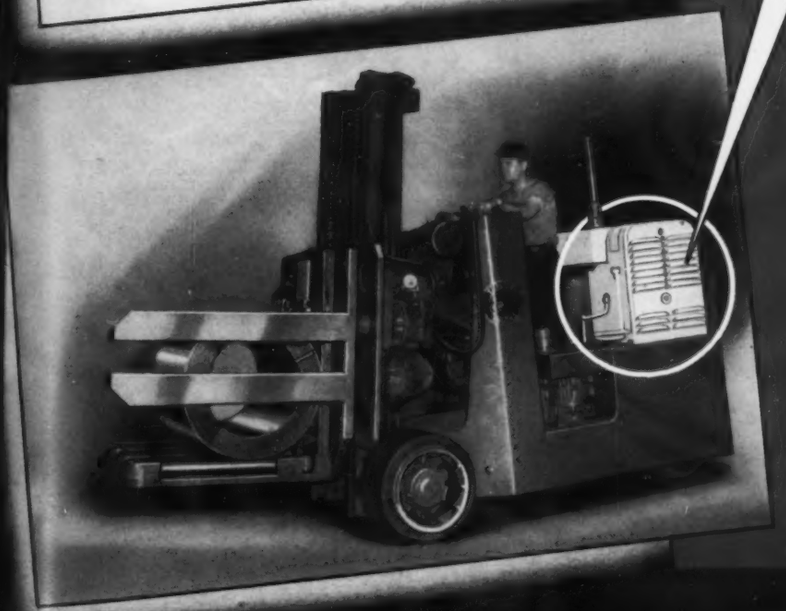

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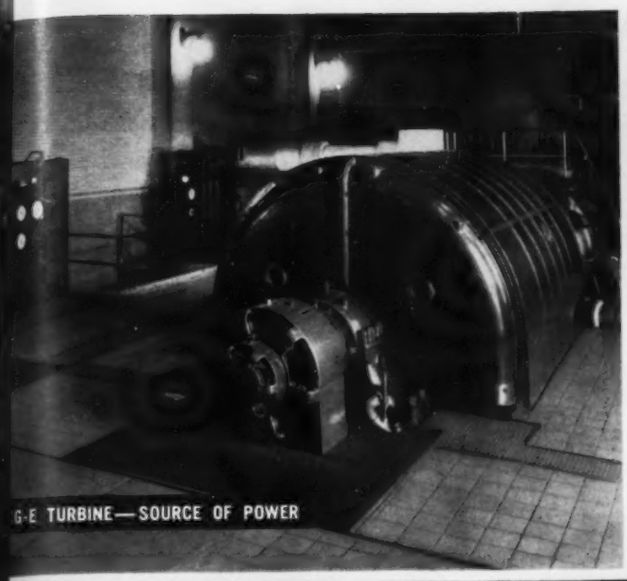
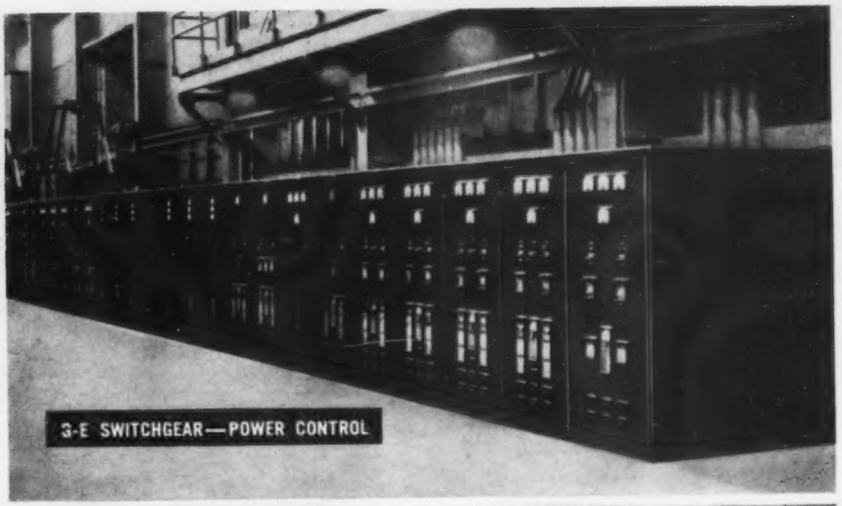
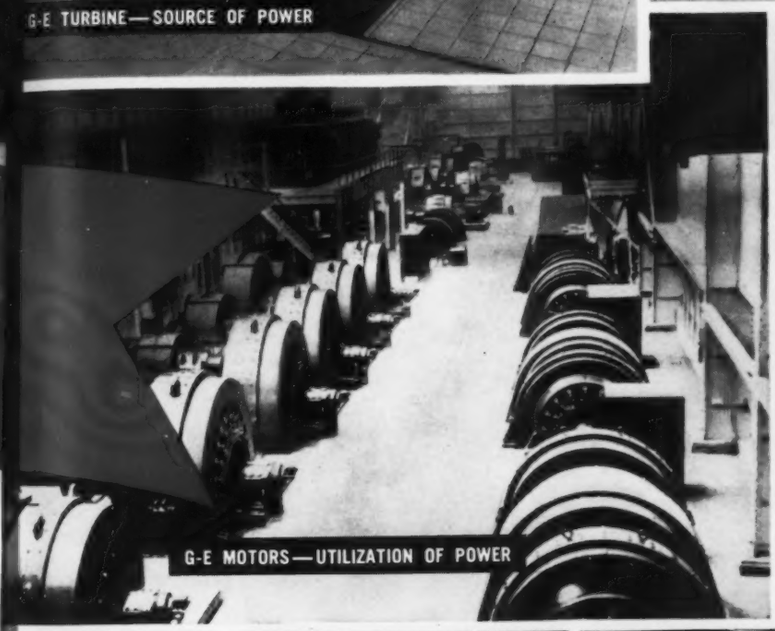


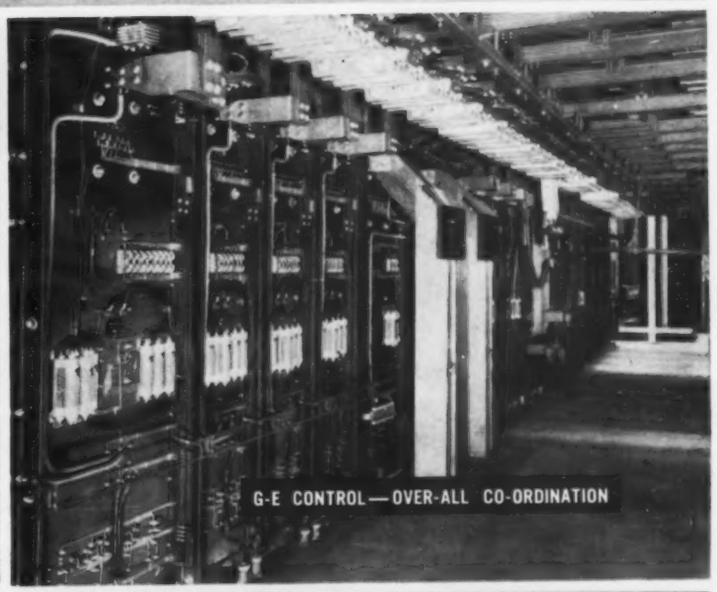
G-E TURBINE—SOURCE OF POWER



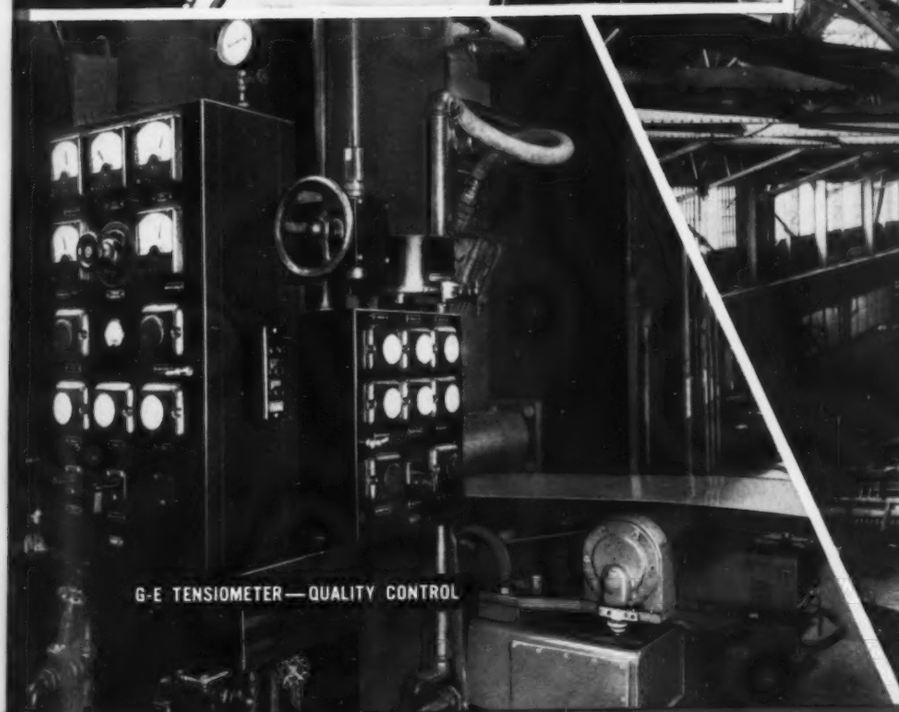
3-E SWITCHGEAR—POWER CONTROL



G-E MOTORS—UTILIZATION OF POWER



G-E CONTROL—OVER-ALL CO-ORDINATION



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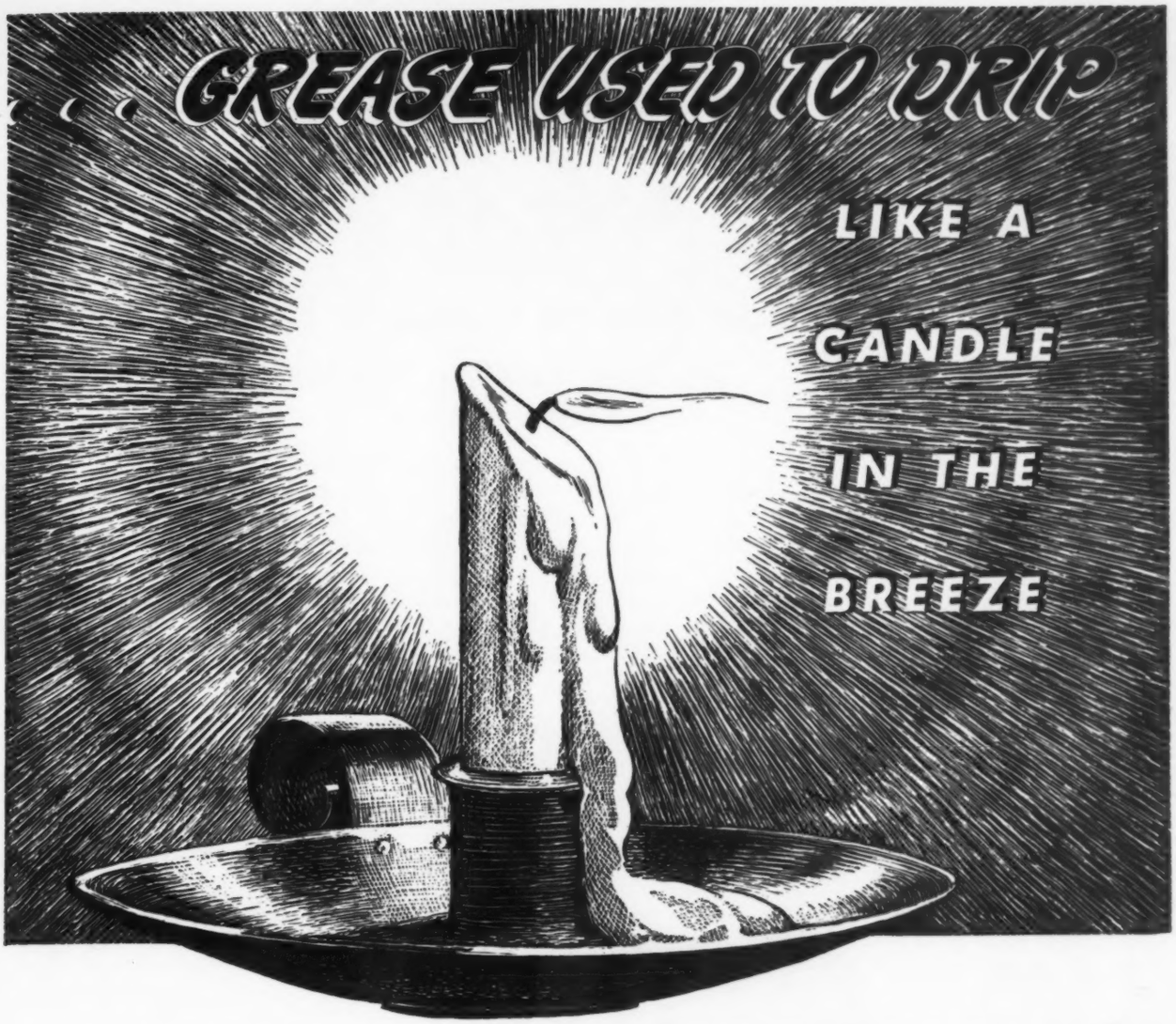

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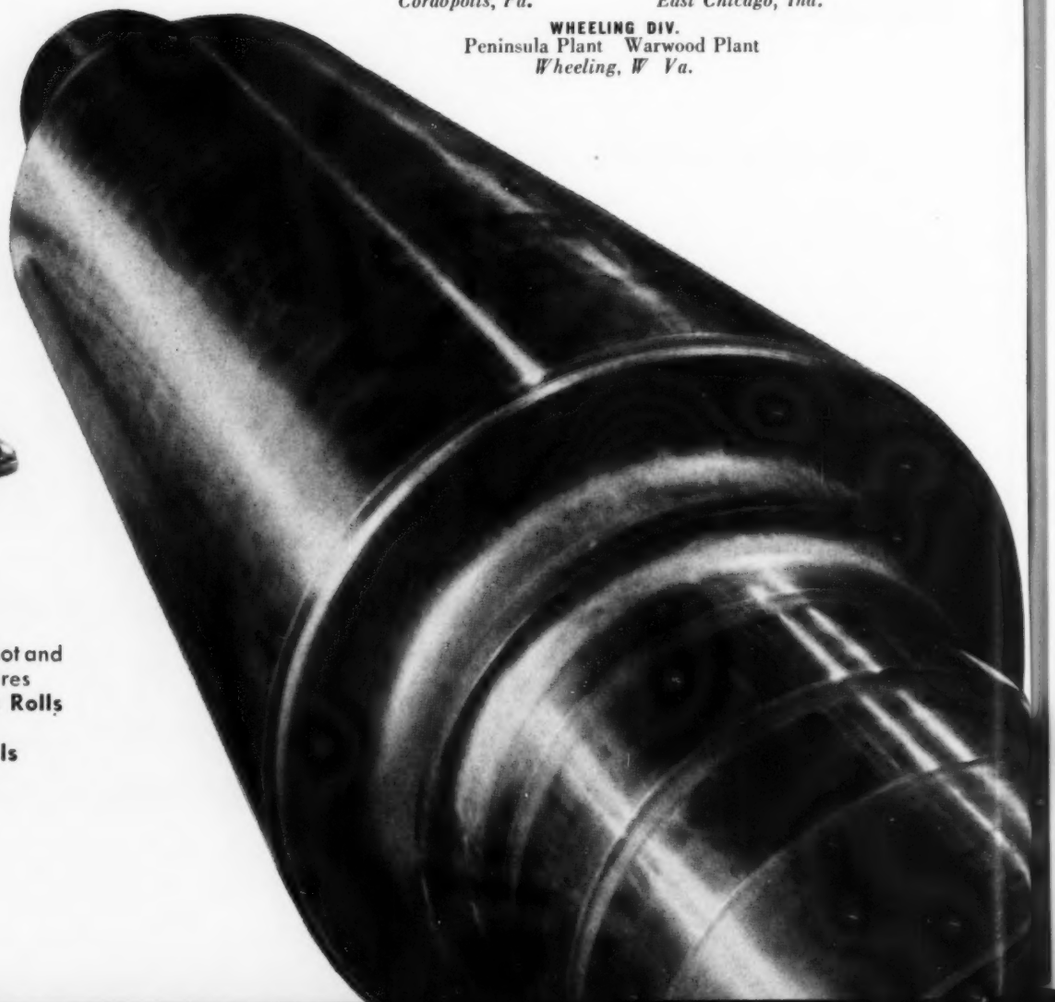

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The NEWS DEFENSE EDITION

VOLUME XVIII NUMBER 9 SEPTEMBER 1941 CLEVELAND, OHIO

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FOR DIFFERENT SEASONS

Many Gas Companies furnish gas at an especially attractive rate when used on an off-peak contract. The above system fills the requirements of standby equipment and simplicity of changeover. It is also being used by farsighted plant managers who fear that world conditions may change their fuel position.

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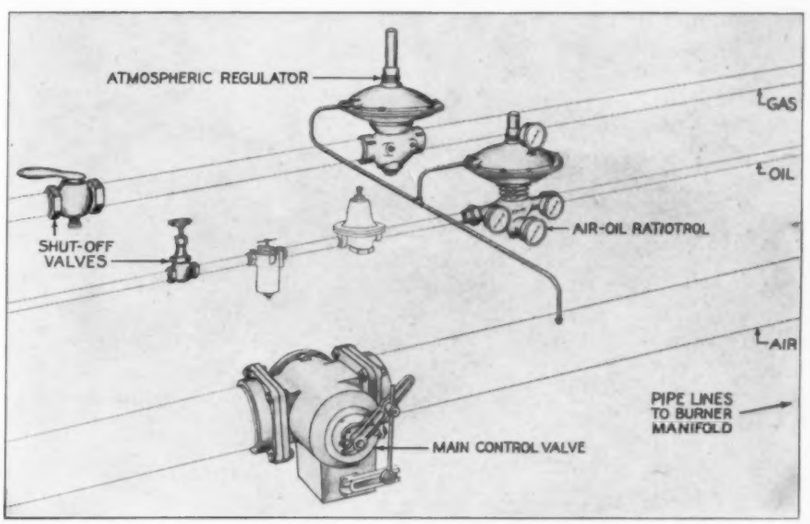
By changing the insert of the standard Luminous Flame gas burners, a low pressure air atomizing oil burner can be provided. The same air valve controls the air and gas or oil supplied to the burners.

One Air Valve Controls Fire For Any Number Burners Either Gas or Oil

Fuel-Air Ratio Automatically Controlled By Pressures



In the North American pressure system of proportioning, the oil or gas is directly proportional to the air pressure on the downstream side of the main air control valve. Thus, air or fuel pressure variation, or number of burners in operation have no effect on fuel-air ratio, and thus maximum efficiencies are maintained.

Furthermore, the firing rate or fuel-air ratio of any burner can be changed in respect to the other burners without affecting their fuel-air ratio.

We cordially invite you to write for Engineering Data. The North American Manufacturing Co., 2910 E. 75th St., Cleveland, Ohio.—Adv.

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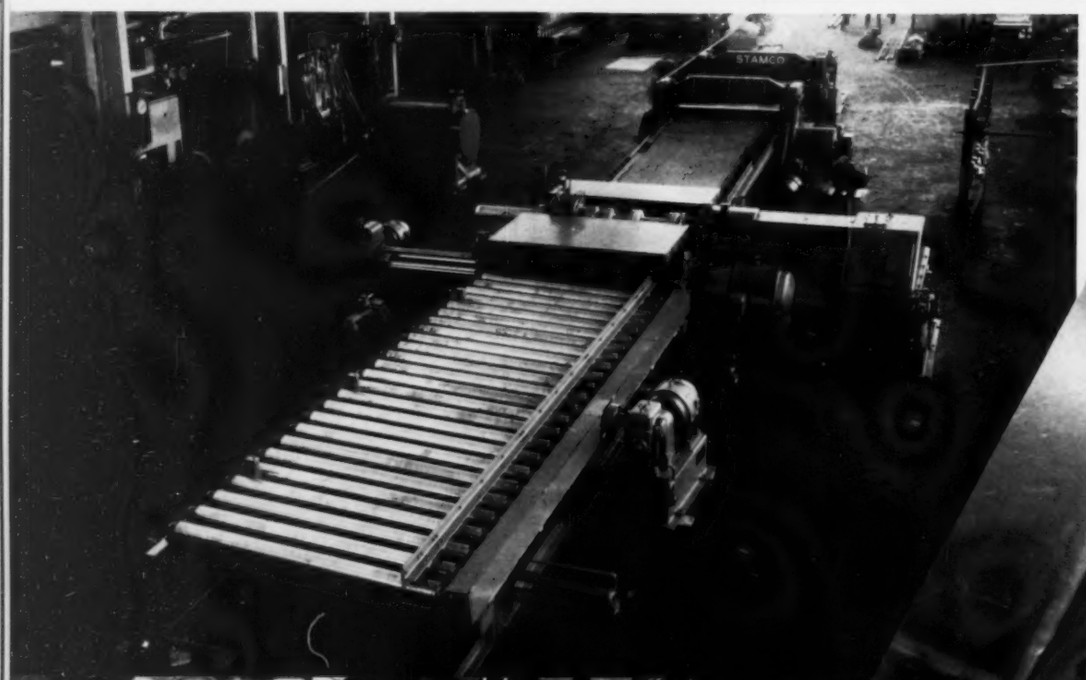

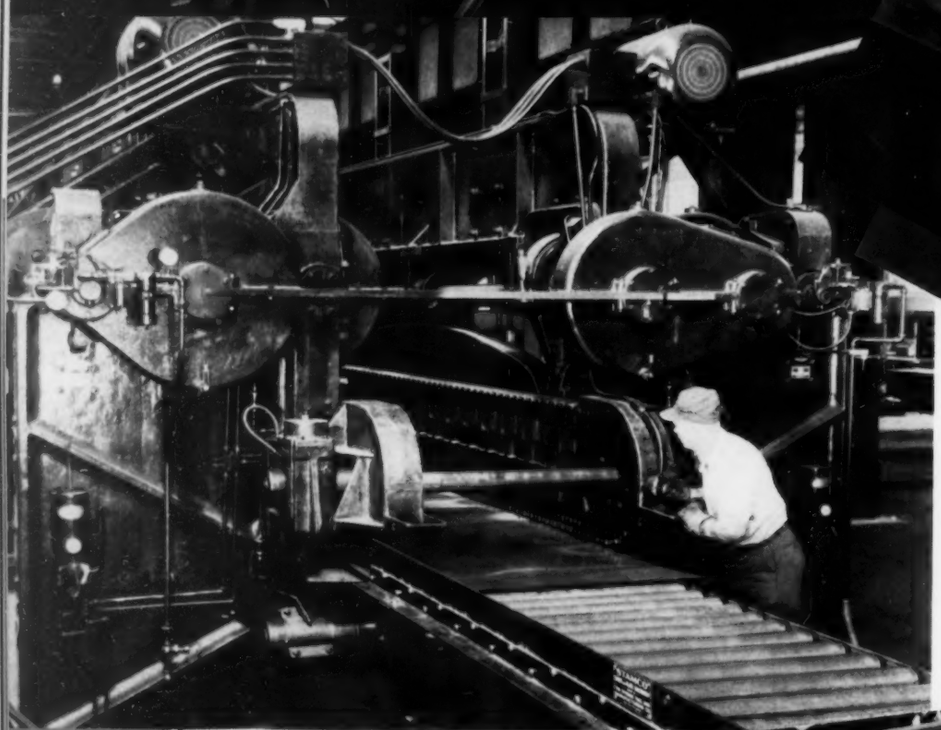

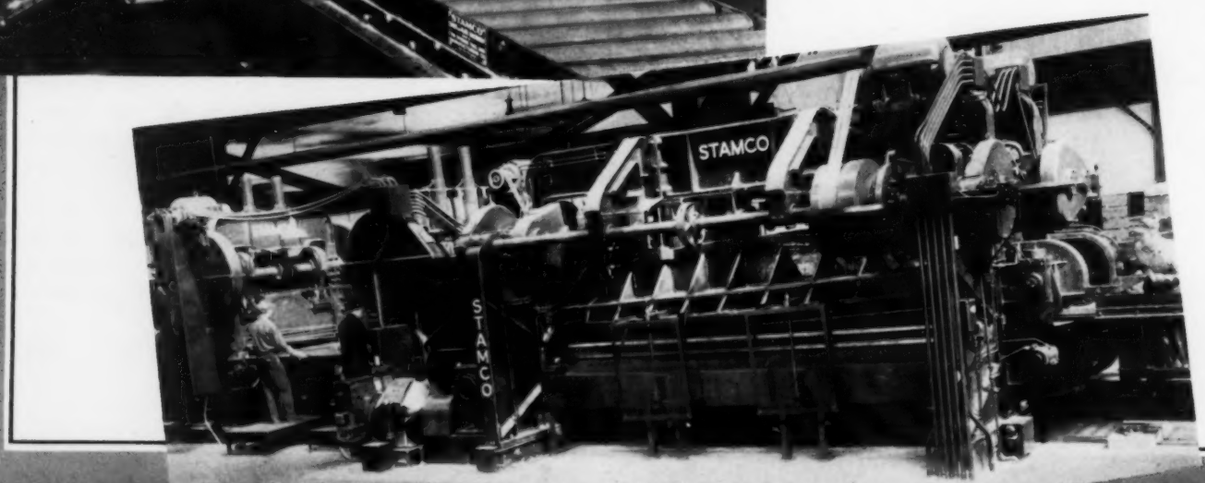

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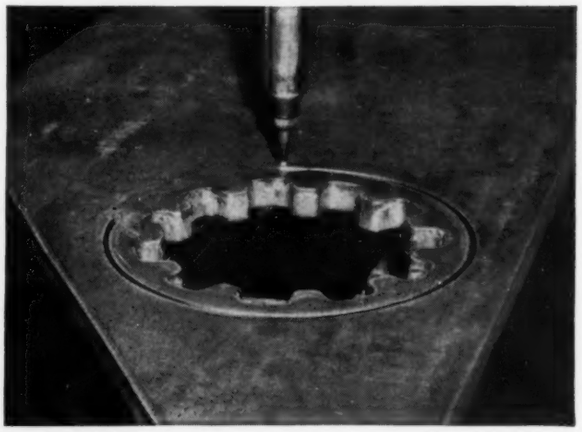

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You can also learn more about the availability of Linde products, and the Linde service which helps Linde customers get good results from use of Linde processes.

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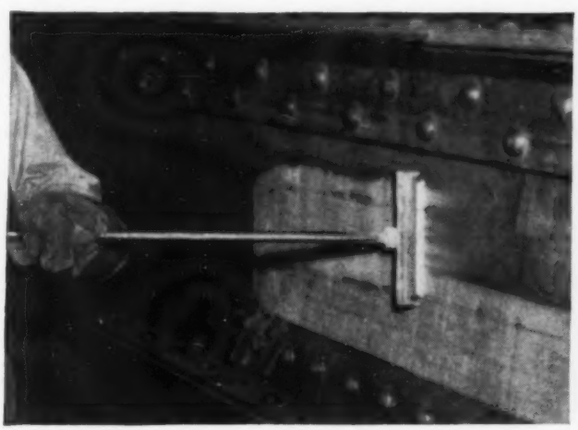
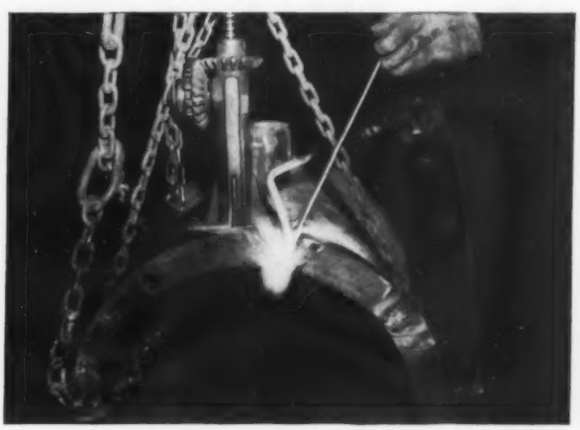


Before paint is applied—Flame-priming of structural steel before painting pops off loose scale and drives out surface moisture. The paint flows on the warm metal faster, bonds tighter, dries quicker, and lasts longer.



When vital parts break or wear—Shutdowns frequently can be avoided by repairing broken gears, engine heads, brackets, and other parts, right on the job, by bronze-welding. Worn parts can be economically reclaimed.

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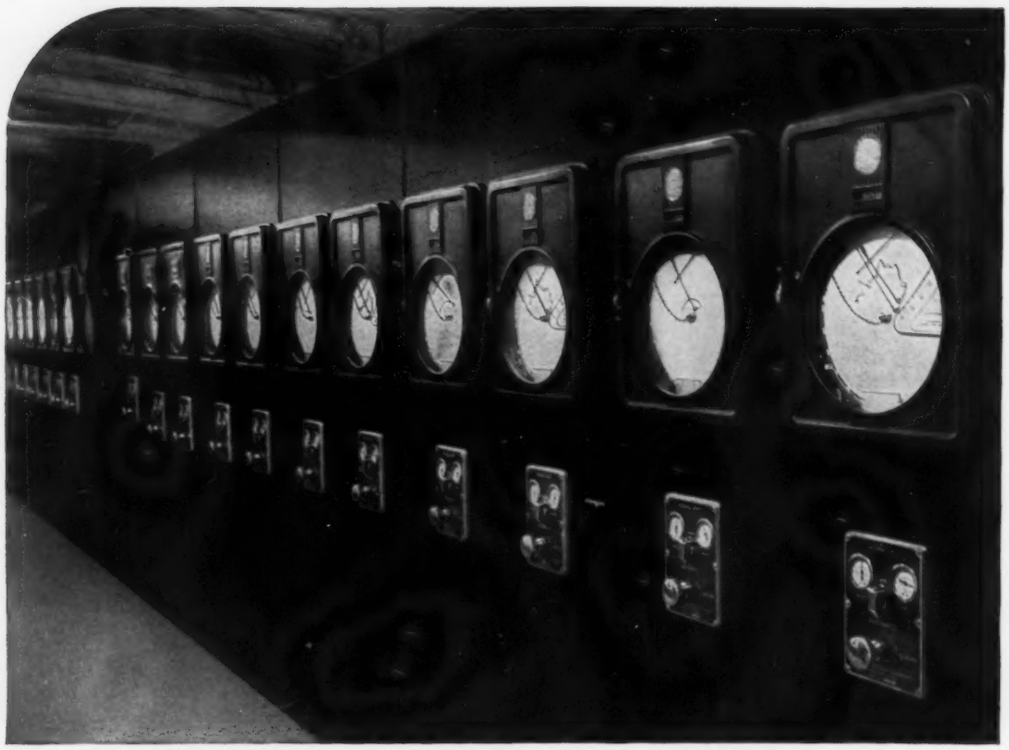


This installation of Bailey Meter Control on gas fired boilers at The Colorado Fuel and Iron Co. paid for itself in Six Months.

COMBUSTION CONTROL "PAYS OUT" IN 6 MONTHS

COMPLETE CONTROL AT MINNEQUA WORKS RAISES EVAPORATION RATIO FROM .486 TO .593 POUNDS PER CUBIC FOOT OF GAS

● Late in 1938 The Colorado Fuel and Iron Co. installed Bailey Meter Control on one boiler. Satisfactory results obtained from this first test installation were responsible for the installation of Bailey Meter Control on four additional boilers during the early part of 1939.

At the end of 1939, a comparison of evaporation ratios obtained with and without automatic control indicated that Bailey Meter Control had increased this figure from .486 to .593 pounds per cubic foot of natural gas. This increase represents a rate of fuel saving sufficient to pay off the entire cost of the Bailey Meter Control in six months.

Because of these results, Bailey Meter Control was ordered for ten more boilers.

The installation of COMPLETE Combustion Control which: (1) Automatically maintains desired steam pressure; (2) Automatically maintains most economical fuel—air ratio; (3) Automatically maintains the division of load between boilers; (4) Automatically maintains desired furnace draft; is one of the few "high return" investments open to your company today. Send for your copy of Bulletin No. 102-C describing Bailey Meter Control.

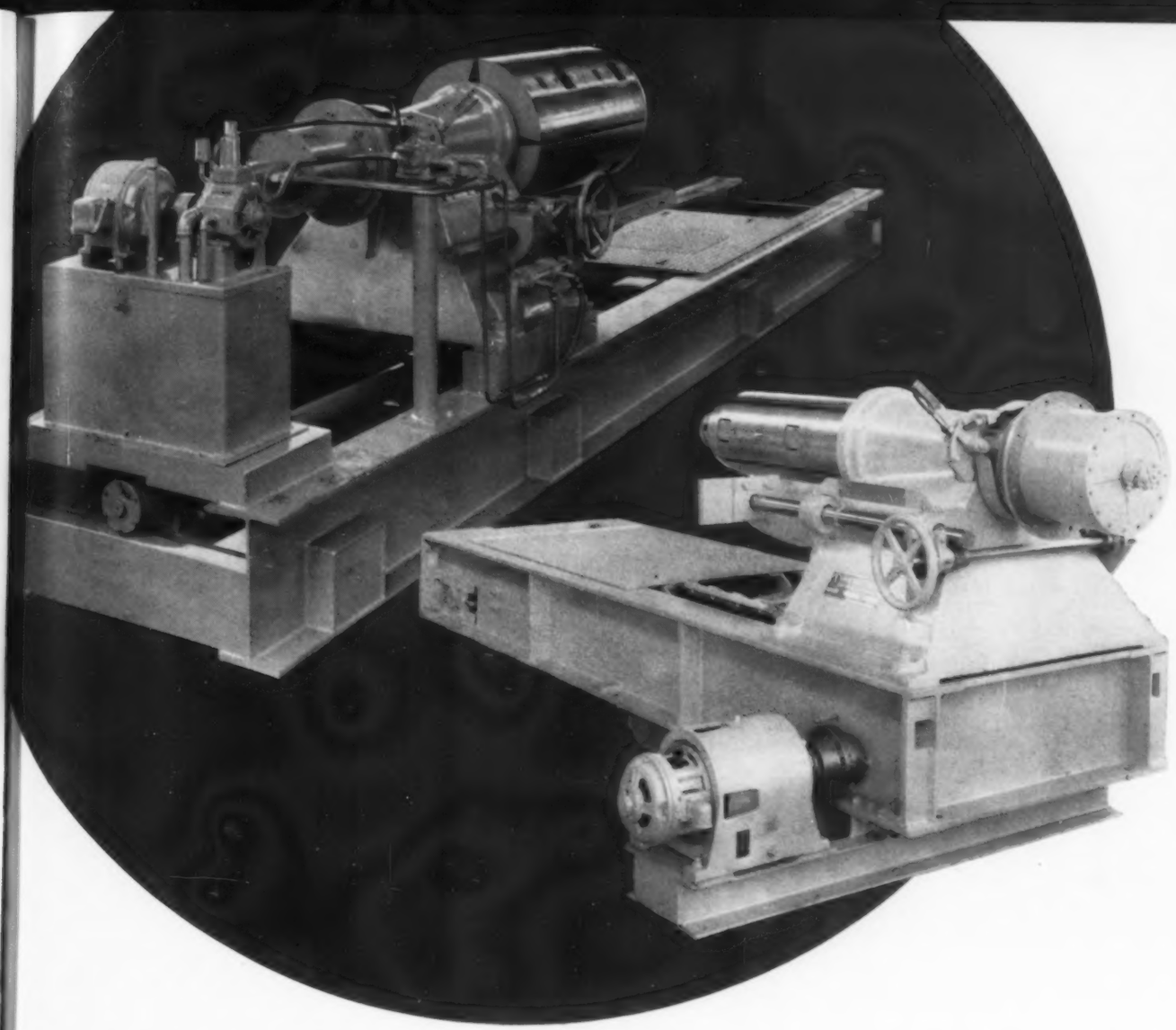
BAILEY METER COMPANY
1047 IVANHOE ROAD • CLEVELAND, OHIO
Bailey Meter Company Limited, Montreal, Canada A60-1A

BAILEY METERS

BAILEY METER CONTROL

The Complete Combustion Control System

BOILER METERS • MULTI-POINTER GAGES • FLUID METERS • RECORDERS • SUPERHEAT CONTROL • DESUPERHEAT CONTROL • COMBUSTION CONTROL • FEED WATER CONTROL



FOR RAPID HANDLING OF WIDE *Strip Steel..*

AETNA-STANDARD MANDREL TYPE PAY-OFF REELS • • •

• **FEATURES:** Rapid Loading • Handles Coils of Varying Inside Diameter With No Adjustment • Heavy Back Tension Without Coil Damage • Automatic Coil Centering Device • Hydraulic or Mechanical Lift and Traverse • Air or Hydraulic Head Expansion Up to Seven Inches • Removable Shoes for Greater Coil Sizes • Regenerative or Hand Braking • Payoff Drive.

Manufactured and sold under patents and patents pending.

The **AETNA-STANDARD**
ENGINEERING COMPANY
★ YOUNGSTOWN, OHIO, U.S.A. ★

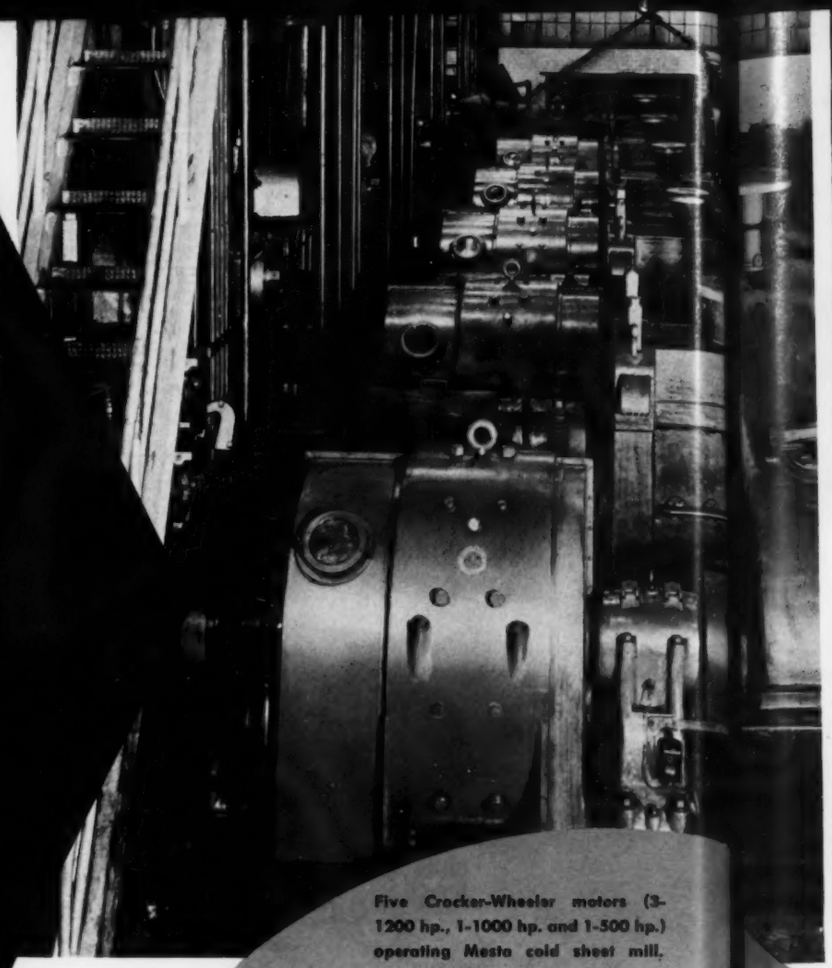
ASSOCIATED COMPANIES

HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND • AKTIEBOLAGET ARBOGA MEKANISKA VERKSTAD, ARBOGA, SWEDEN • JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

Designers and Builders to the Steel, Non-ferrous and Chemical Industries

CROCKER-WHEELER

STEEL INDUSTRY

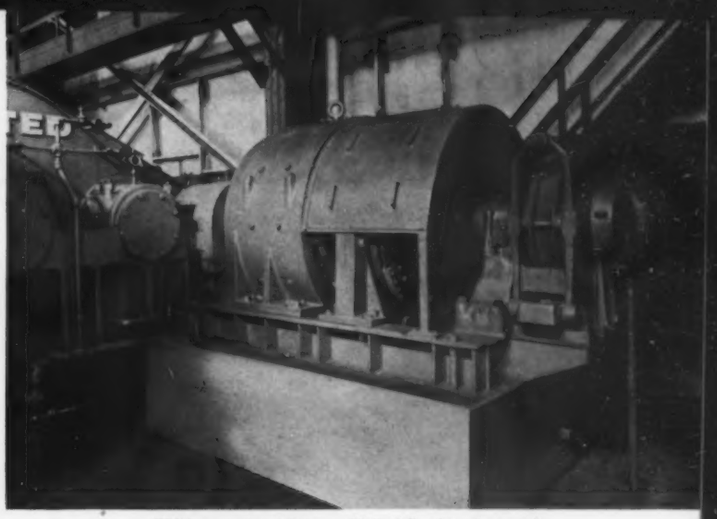


Five Crocker-Wheeler motors (3-1200 hp., 1-1000 hp. and 1-500 hp.) operating Mesta cold sheet mill.

ADJUSTABLE SPEED

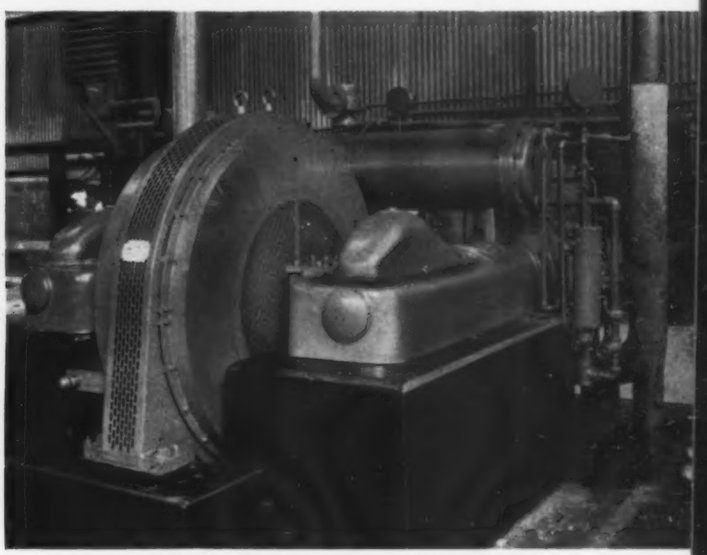
When adjustable-speed motors are required, consult Crocker-Wheeler. A great deal of experience is at your service—long years of building direct-current, adjustable-speed motors (speed adjusted by field control or by voltage control); of building slip-ring, variable-speed motors, or squirrel-cage, multi-speed motors. The addition of the a.c. Polyspeed motor places us in position to make unbiased recommendations for any application. *If you have an adjustable-speed problem, consult Crocker-Wheeler.*

3500 kw. synchronous motor-generator set supplying power for a cold sheet mill.



700 hp. motor driving a United Engineering and Foundry Co. slab reducer in an Ohio mill.

Two "SWS" motors operating coilers. Over two-hundred Crocker-Wheeler mill motors are installed in this mill.



150 hp. synchronous motor driving an Ingersoll Rand compressor in a Mid-western steel plant.

CROCKER-WHEELER built the first genuine steel-mill motor—back in 1904. The first motor designed specifically for operating steel-mill auxiliaries.

Existing motors were far from satisfactory; steel engineers wanted insulation that could withstand the injurious effects of moisture, dust, fumes and terrific heat. The motor then pioneered by Crocker-Wheeler proved a success.

Today, modern "SWS" Mill Motors (built to meet the standards of the Association of Iron & Steel Engineers) are likewise designed specifically for the steel industry. These motors withstand high temperatures, heavy overloads and corrosive fumes—they are motors that can be installed and then forgotten. Hundreds of "SWS" motors are now installed in steel mills throughout the country.

Other products, which Crocker-Wheeler has been building for steel mills for many years, include: Direct-current motors for main roll drive, and for operating slab squeezers, trimming shears, levellers, etc.; motor-generator sets to supply power for main roll drives and for auxiliary motors; induction motors for a variety of applications; synchronous motors and Crocker-Wheeler Resilient Flexible Couplings.

We would welcome your inquiry for complete data on "SWS" Mill Motors—pioneered by Crocker-Wheeler. Or on any of the other lines of motors and generators listed on the opposite page. Or on flexible couplings. Please write on your business or professional letterhead.

CROCKER-WHEELER

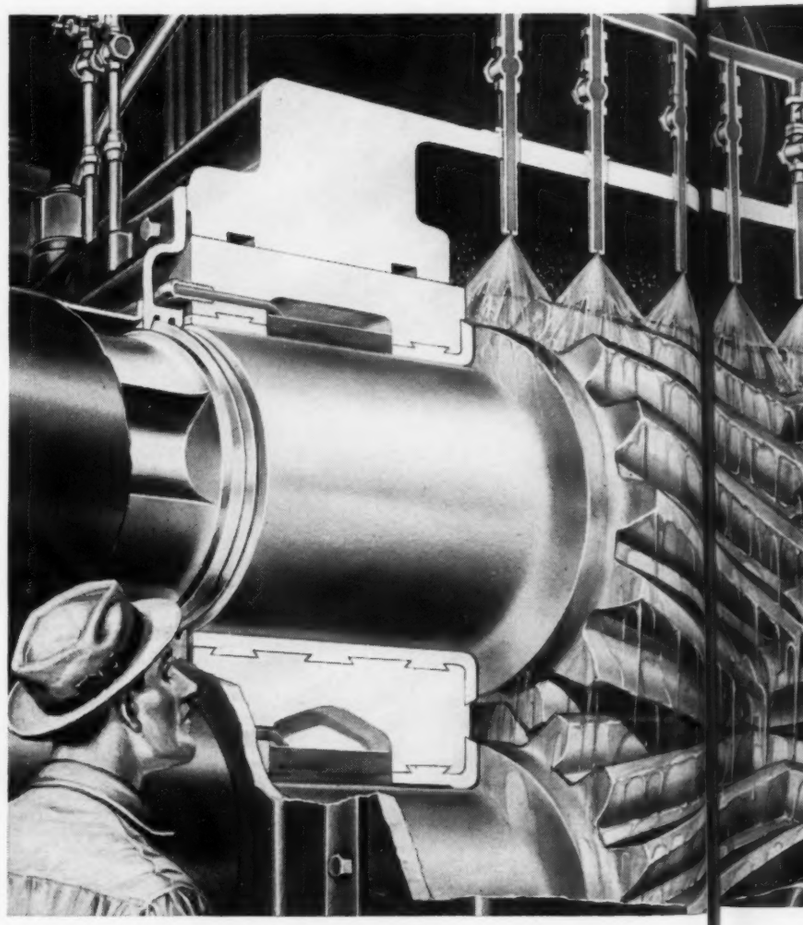
Gargoyle Compound —
Oil that Resists

PINION-STAND GEARS may be subject to crushing tooth pressures. That means "boundary lubrication." Under that condition, maximum film strength is necessary.

Gargoyle Compound is made to give maximum film strength!

This unique lubricant is ideal where crushing pressures exist. It combines film strength with the stability necessary to assure long oil life in the circulation systems of pinion-stand gears.

You get protection both ways—safety plus economy.



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SOCONY-VACUUM OIL COMPANY, INC. • Standard Oil of New York Div. • White Star Div. • Lubrite Div. • Chicago Div. • White Eagle Div. • Wadhams Div. • Southeastern Div. (Baltimore) • Magnolia Petroleum Co. • General Petroleum Corp. of Calif.

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The Emblem of
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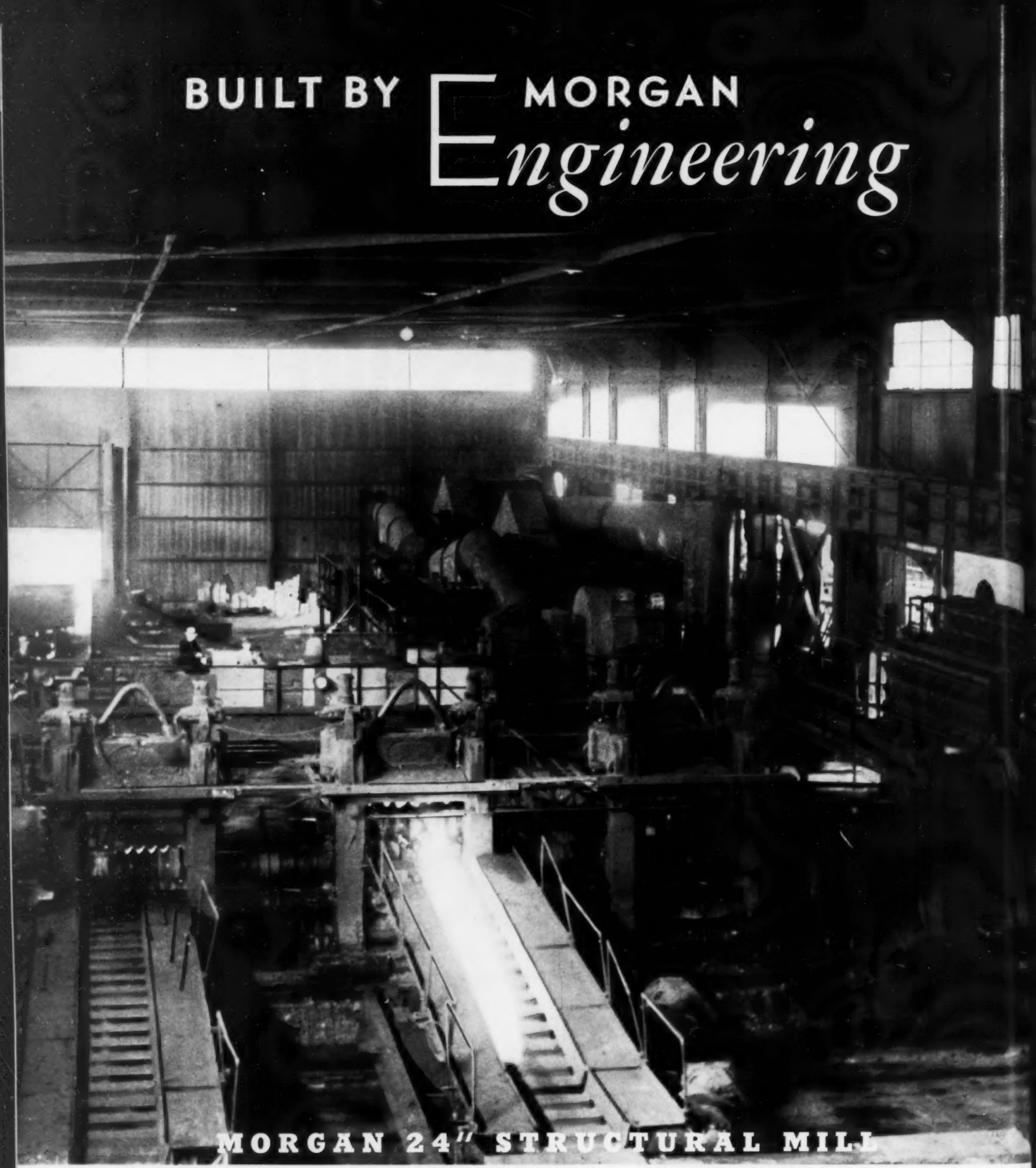
"Correct Lubrication"

YOU'LL BENEFIT FROM: 75 YEARS' LUBRICATION EXPERIENCE • PRODUCTS APPROVED BY ENGINE BUILDERS •

BUILT BY MORGAN *Engineering*



MORGAN 24″ STRUCTURAL MILL

● Among the many types of mill equipment built by Morgan is the above 24″ structural mill, consisting of three three-high stands served on each side by two traveling tilting tables and tail tables with transfers.

A two-high finishing mill located about 170′-0″ beyond was also furnished. In addition, all necessary auxiliary equipment to handle billets and rolled shapes to the finished product was furnished with this installation.

★ **DESIGNERS • MANUFACTURERS • CONTRACTORS**

BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS

★ ELECTRIC TRAVELING CRANES • CHARGING MACHINES

INGOT STRIPPING MACHINES • SOAKING PIT CRANES

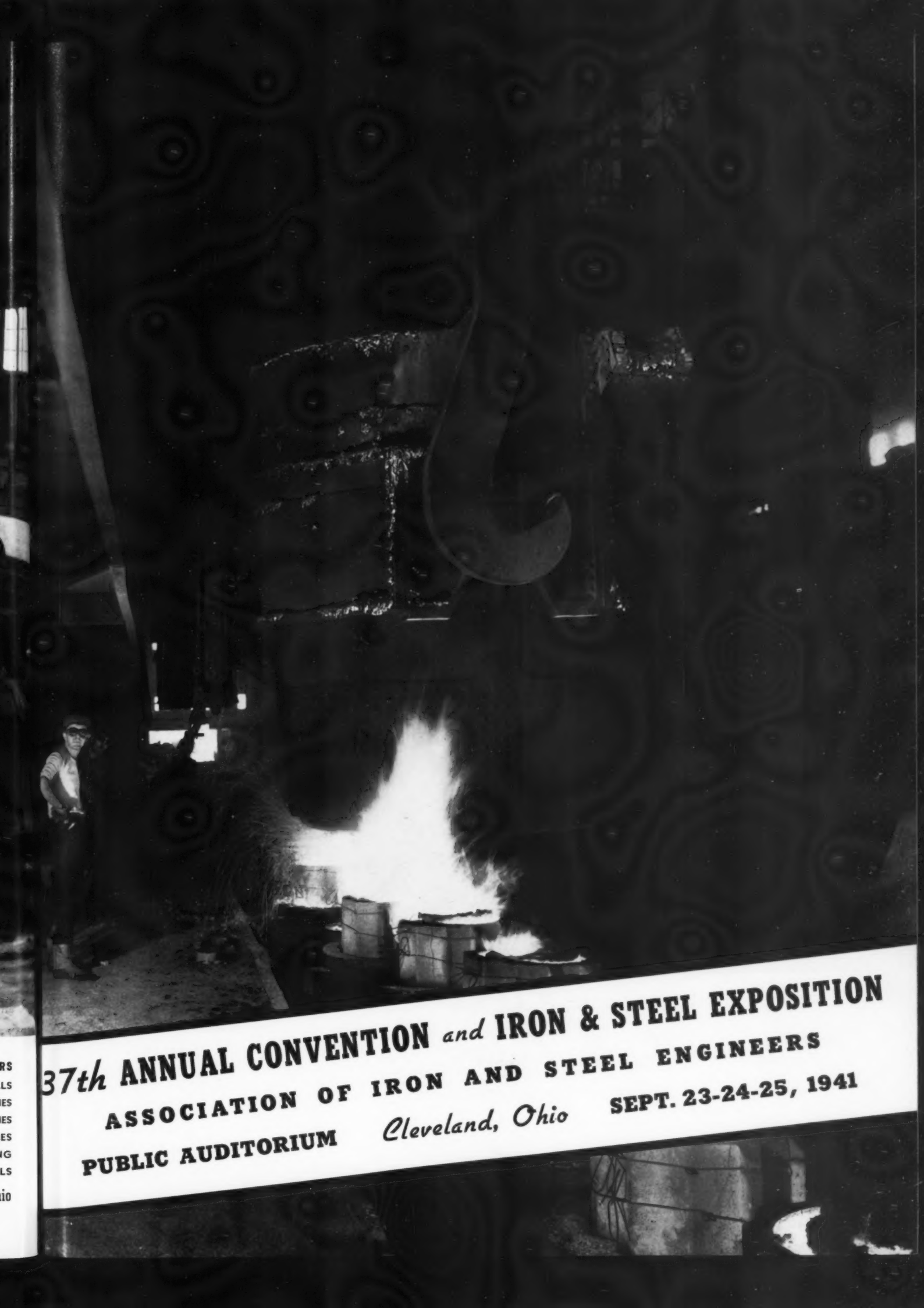
★ ELECTRIC WELDED FABRICATION • LADLE CRANES

STEAM HAMMERS • STEAM HYDRAULIC FORGING

★ PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

★ THE MORGAN ENGINEERING CO., Alliance, Ohio

Pittsburgh, 1420 Oliver Building



37th ANNUAL CONVENTION and IRON & STEEL EXPOSITION

ASSOCIATION OF IRON AND STEEL ENGINEERS

PUBLIC AUDITORIUM *Cleveland, Ohio* SEPT. 23-24-25, 1941

Host to the Convention

E. J. Kulas

PRESIDENT, OTIS STEEL COMPANY

THE OTIS STEEL COMPANY

PLATES, SHEETS, STRIP STEEL
STEEL CASTINGS, PIG IRON

E. J. KULAS
PRESIDENT

CLEVELAND, O.

August 18, 1941.

Association of Iron and Steel Engineers
Empire Building
Pittsburgh, Pennsylvania

Gentlemen:

On behalf of The Otis Steel Company I want to welcome the members of the Association of Iron and Steel Engineers to visit our Riverside plant during their meeting in Cleveland in September.

It has become the accepted practice of the industry's engineers to compare notes and exchange information on many common operating problems. Certainly today when American industry is going "all out" for national defense, the pooling of information and the interchange of ideas on how best to meet the challenge to double, treble, and in many instances quadruple the production of vital defense materials assumes an extraordinary importance.

You have my best wishes for a convention that will fortify your membership with increased ability to handle the load which the steel industry must carry as its share in the successful defense of our democracy.

Very cordially yours

E. J. Kulas

President

William A. Perry

PRESIDENT, ASSOCIATION OF IRON AND STEEL ENGINEERS

It is with a distinct sense of pleasure that the Association of Iron and Steel Engineers greets the engineers and operators of the iron and steel industry at the 37th Annual Convention and Iron and Steel Exposition.

Firmly believing that participation in these activities will open up new channels of thought leading to improvements in our daily work, we sincerely hope that each and every one in attendance will take full advantage of the opportunities offered. If this is done conscientiously, the benefits to the individuals, to the industry and to the national defense program will be manifold.

Convention Committees

GENERAL CHAIRMAN OF CONVENTION AND EXPOSITION

Chairman
W. A. Perry
Superintendent, Electric and Power Department
Inland Steel Company
East Chicago, Indiana

Vice Chairman
Elmer J. Wagar
Assistant Chief Engineer
Otis Steel Company
Cleveland, Ohio

GENERAL CONVENTION COMMITTEE

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T. E. Hughes
Superintendent, Maintenance
Carnegie-Illinois Steel Corporation
Duquesne, Pennsylvania

Vice Chairman
A. S. Glossbrenner
Superintendent, Hot Strip Mill
Youngstown Sheet and Tube Company
Youngstown, Ohio

REGISTRATION COMMITTEE

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Superintendent, Light and Power
Carnegie-Illinois Steel Corporation
Youngstown, Ohio

Vice Chairman
E. C. McDonald
Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

IRON AND STEEL EXPOSITION COMMITTEE

Chairman
Frank D. Egan
Electrical Superintendent
Bethlehem Steel Company
Lackawanna, New York

Vice Chairman
P. J. Bowron
Assistant Superintendent, Annealing Department
Tennessee Coal, Iron and Railroad Company
Birmingham, Alabama

COMMITTEE ON ATTENDANCE

Chairman
A. D. Brodie
Superintendent, 93 in. Cold Strip Mill and Galvanizing Department
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

Vice Chairman
Stanley Grand-Girard
Electrical and Mechanical Superintendent
Sharon Steel Corporation
Sharon, Pennsylvania

FORMAL RECEPTION COMMITTEE

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W. A. Perry
Superintendent, Electric and Power Department
Inland Steel Company
East Chicago, Indiana

Vice Chairman
J. D. Donovan
Massillon, Ohio

LOCAL CLEVELAND DISTRICT SECTION ENTERTAINMENT COMMITTEE

General Chairman

Elmer J. Wagar

T. B. McElray
George H. Rose
W. T. Adams

Stanley Grand-Girard
A. C. Shepherd
F. J. Dahleiden

James C. Addleman
I. N. Tull
W. W. Spanagel

Social Activities

ANNUAL CONVENTION

TUESDAY, SEPTEMBER 23

9:00 A.M.—Ladies' Registration, Parlor K, Hotel Statler

12:30 P.M.—Luncheon and Musical Style Lecture, Crane's Canary Cottage, Chagrin Falls, Ohio. Buses leave from Hotel Statler, 12:30 P.M.

10:00 P.M.—Exhibitors' Dance, Grand Ball Room, Hotel Statler

WEDNESDAY, SEPTEMBER 24

7:30 P.M.—Formal Banquet and Dance, Grand Ball Room, Hotel Statler

Speakers: E. J. Kulas, *President, Otis Steel Company*

James R. Young, *Journalist*

THURSDAY, SEPTEMBER 25

1:30 P.M.—Inspection Tour and Fashion Tea, Halle Brothers, Cleveland, Ohio

Inspection Trip

OTIS STEEL COMPANY

CLEVELAND, OHIO

September 24, 1941 **1:30 P. M.**

On Wednesday afternoon, September 24, members and guests of the Association will visit the Riverside Plant of the Otis Steel Company. The buses for this trip will depart from the Cleveland Public Auditorium at 1:30 P.M. Everyone must use the transportation facilities as provided by the Association, otherwise they will not be permitted to enter the plant. Please make reservations and obtain tickets as soon as possible at the registration headquarters in the Cleveland Public Auditorium.

View of 77 in. continuous strip mill to be inspected by Association during convention.

All ACTIVITIES U

CLEVELAND PUBLIC

Tuesday, SEPTEMBER 23

Iron and Steel Exposition—9:00 A.M.–10:00 P.M.

9:00 A.M.—REGISTRATION—Main Lobby

Chairman:
T. B. McELRAY
Superintendent, Light and Power
Carnegie-Illinois Steel Corporation
Youngstown, Ohio

Vice-Chairman:
E. C. McDONALD
Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

9:00 A.M.—LADIES' REGISTRATION—Hotel Statler, Parlor K.

9:15 A.M.—BUSINESS SESSION—Club Room B

Chairman:
W. A. PERRY
Superintendent, Electric and Power Department
Inland Steel Company
East Chicago, Indiana

Vice-Chairman:
J. L. MILLER
Assistant Chief Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

9:30 A.M.—ELECTRICAL ENGINEERING DIVISION—Club Room B

Chairman:
K. E. DINIUS
Electrical Engineer
Carnegie-Illinois Steel Corporation
Chicago, Illinois

Vice-Chairman:
H. R. FORD
Electrical Engineer
Wheeling Steel Corporation
Steubenville, Ohio

"Report of Crane Specification Committee," by F. W. Cramer, *Electrical Engineer,* Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

"Ore Bridges," by George Wolfe, *Special Engineer,* Dravo Corporation, Pittsburgh, Pennsylvania.

"Transmitting Torque from Electric Motors," by A. M. MacCutcheon, *Vice President in Charge of Engineering,* Reliance Electric and Engineering Company, Cleveland, Ohio.

1:30 P.M.—MECHANICAL ENGINEERING DIVISION—Club Room B

Chairman:
J. D. JONES
Chief Engineer
Youngstown Sheet and Tube Company
Youngstown, Ohio

Vice-Chairman:
J. E. GRAF
Assistant Chief Engineer
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

"Design and Operation of the Bessemer Convertor," by D. R. Loughrey, *Assistant General Superintendent,* Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

"Rolling Pressures in the Strip Mill," by M. D. Stone and J. I. Greenberger, United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

1:30 P.M.—WELDING ENGINEERING DIVISION—Club Room A

Chairman:
A. W. STEED
Maintenance Superintendent
American Rolling Mill Company
Middletown, Ohio

Vice-Chairman:
STANLEY GRAND-GIRARD
Electrical and Mechanical Superintendent
Sharon Steel Corporation
Sharon, Pennsylvania

"Advanced Methods of Welding," by E. W. P. Smith, *Consulting Engineer,* Lincoln Electric Company, Cleveland, Ohio.

"Electric Welding Machines," by C. H. Jennings and A. B. White, Research Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"Welding in Cold Strip Processing," by J. H. Cooper, *Welding Engineer,* Taylor Winfield Company, Warren, Ohio.

12:30 P.M.—LADIES' LUNCHEON—Canary Cottage, Chagrin Falls, Ohio. Buses leave from Hotel Statler.

10:00 P.M.—EXHIBITORS' DANCE—Grand Ball Room, Hotel Statler—Informal

Wednesday, September 24

Iron and Steel Exposition—9:00 A.M.–10:00 P.M.

9:00 A.M.—COMBUSTION ENGINEERING DIVISION—Club Room B

Chairman:
A. J. FISHER
Fuel Engineer
Bethlehem Steel Company
Sparrows Point, Maryland

Vice-Chairman:
P. C. SINGLETON
Assistant Steam Engineer
Inland Steel Company
East Chicago, Indiana

"Recent Advances in Control of Multi-Fuel Fired Furnaces," by J. C. Vaaler, Askania Regulator Company, Chicago, Illinois.

"Modern Designs of Annealing Covers," by Lee Wilson, *President,* Lee Wilson Engineering Company, Cleveland, Ohio.

"Submerged Heating for Pickling Baths," by W. G. See, The Submerged Combustion Company of America, Inc., Hammond, Indiana.

9:00 A.M.—OPERATING PRACTICE DIVISION—Club Room A

Chairman:
C. P. BETZ
Assistant Manager
Hanna Furnace
Great Lakes Steel Corporation
Ecorse, Michigan

Vice-Chairman:
P. V. MARTIN
Assistant Divisional Superintendent
Coke Plant and Blast Furnace
Carnegie-Illinois Steel Corporation
Gary, Indiana

UNDER *One* ROOF

AUDITORIUM

"Effect of Rate of Operation in the Coke Plant," by B. J. C. van der Hoeven, *General Superintendent*, Koppers Company, Pittsburgh, Pennsylvania.

"Modern Sintering Plant Design and Construction," by M. F. Morgan, *Engineer*, Republic Steel Corporation, Cleveland, Ohio.

"Control of the World's Reserves of Steel Making Materials," by Charles Hart, Charles Hart and Associates, Chester, Pennsylvania.

1:30 P.M.—INSPECTION TRIP: Otis Steel Company, Cleveland, Ohio. Buses will leave Cleveland Public Auditorium.

7:30 P.M.—FORMAL BANQUET AND DANCE
—Grand Ball Room, Hotel Statler
Speakers: E. J. Kulas, *President*, Otis Steel Company; and James R. Young, *Journalist*.

Thursday, September 25

Iron and Steel Exposition—9:00 A.M.–10:00 P.M.

9:00 A.M.—ELECTRICAL ENGINEERING DIVISION—Club Room B

Chairman:
J. S. MURRAY
Chief Electrical Engineer
Follansbee Steel Corporation
Follansbee, West Virginia

Vice-Chairman:
J. I. KASPARI
Electrical Engineer
Weirton Steel Company
Weirton, West Virginia

"Report on Field Tests on IR Drop Compensation," by G. E. Stoltz, *Manager*, Metal Working Engineering, Industry Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"The Temper Mill," by T. B. Montgomery, *Control Engineer*, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

"Motor Applications and Power Requirements for Strip Processing Lines," by H. W. Poole, Steel Mill Section, Industrial Engineering Department, General Electric Company, Schenectady, New York.

9:00 A.M.—COMBUSTION ENGINEERING DIVISION—Club Room A

Chairman:
L. N. McDONALD, JR.
Chief Power and Fuel Engineer
Carnegie-Illinois Steel Corporation
Youngstown, Ohio

Vice-Chairman:
E. C. McDONALD
Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

"Modern Bloom and Billet Heating Furnaces," by M. H. Mawhinney, *Consulting Engineer*, Salem, Ohio.

"Fuel Applications in Metallurgical Furnaces," by F. S. Bloom, *President*, Bloom Engineering Company, Pittsburgh, Pennsylvania.

"Organization of Fuel Department Personnel and Practice," by T. J. McLoughlin, *Assistant to Vice President of Operations*, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

1:30 P.M.—OPERATING PRACTICE DIVISION—Club Room B

Chairman:
F. E. FLYNN
District Manager
Republic Steel Corporation
Warren, Ohio

Vice-Chairman:
H. G. R. BENNETT
Engineer, Hot Rolling Mills
Carnegie-Illinois Steel Corporation
Pittsburgh, Pennsylvania

"Procedure in Scarfing High Carbon and Alloy Steels," by G. D. Winlack, *Steel Mill Engineer*, Air Reduction Sales Company, New York, New York.

"Electrolytic Tinplate," by M. D. Stone, United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

"Oxy-Acetylene Defense Developments," by J. H. Zimmerman, *Development Manager*, Linde Air Products Company, New York, New York.

1:30 P.M.—LUBRICATION ENGINEERING DIVISION—Club Room A

Chairman:
T. R. MOXLEY
General Master Mechanic
Wheeling Steel Corporation
Steubenville, Ohio

Vice-Chairman:
C. R. HAND
Lubrication Engineer
Bethlehem Steel Company
Sparrows Point, Maryland

"Diesel Engine Lubrication," by D. N. Evans, *Lubrication Engineer*, Inland Steel Company, East Chicago, Indiana.

"Sealing Methods for Oil Film Bearings," Symposium led by L. F. Coffin, *Superintendent*, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland.

"Filtration and Reclamation of Oils," by C. A. Bailey, *Assistant to Superintendent*, Plant Maintenance, Sheet and Tin Mill Division, Carnegie-Illinois Steel Corporation, Gary, Indiana.

1:45 P.M.—LADIES' STYLE SHOW AND TEA
—Halle Brothers

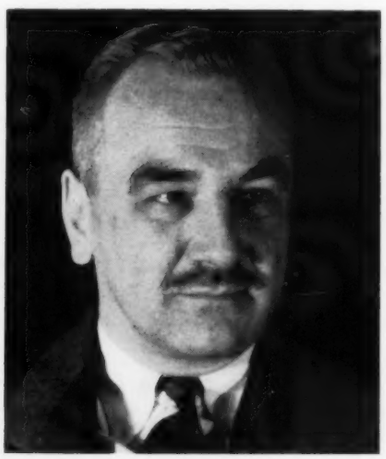
PERTINENT DETAILS

All of the events of the Convention and Exposition, with the exception of the social functions, will be held in the Cleveland Public Auditorium. This is in line with the policy of the Association to maintain at its Annual Conventions all activities under the one roof. The Inspection Trip to Otis Steel Company will depart from the Public Auditorium. The social affairs will all be held at the Hotel Statler, which will be the headquarters Hotel.

PRESIDING OFFICERS and A U

J. I. GREENBERGER

D. R. LOUGHREY



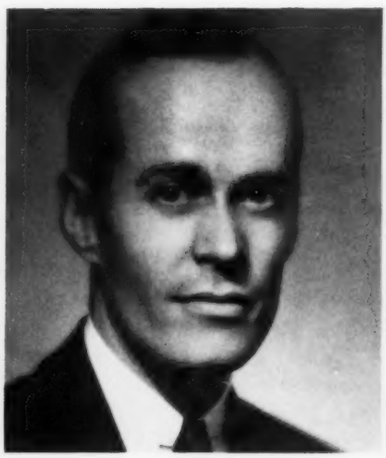
J. H. ZIMMERMAN

B. J. C. VAN DER HOEVEN

J.

C. A. BAILEY

M. H. MAWHINNEY



W. G. SEE

J. H. COOPER

D

F. S. BLOOM

T. B. MONTGOMERY

GEORGE WOLFE

J. S. MURRAY

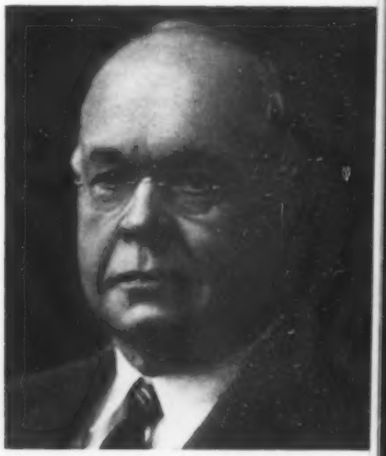
E.

AUTHORS at CONVENTION

J. I. KASPARI

J. C. VAALER

E. J. WAGAR



CHARLES HART

D. N. EVANS

P. J. BOWRON

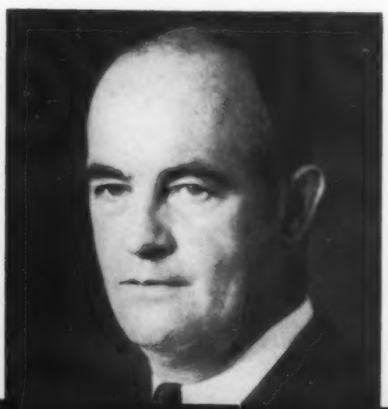
C. P. BETZ

M. D. STONE

E. C. McDONALD

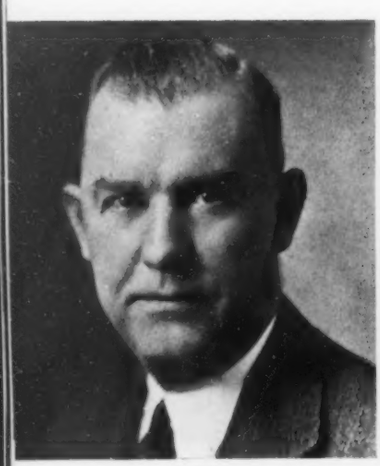
F. W. CRAMER

J. D. JONES



P. C. SINGLETON

PRESIDING OFFICERS and AU



F. D. EGAN

T. E. HUGHES

A. S. GLOSSBRENNER

F. E. FLYNN

A. M.

L. N. McDONALD, JR.

E. W. P. SMITH

K. E. DINIUS

T. B. McELRAY

H.

G. D. WINLACK

H. G. R. BENNETT

L. F. COFFIN

C. H. JENNINGS

P.

AUTHORS at CONVENTION

A. M. MacCUTCHEON

G. E. STOLTZ

T. R. MOXLEY

T. J. McLOUGHLIN

H. W. POOLE

STANLEY GRAND-GIRARD

J. D. DONOVAN

A. W. STEED

P. V. MARTIN

A. J. FISHER

J. L. MILLER

J. E. GRAF

...Don't Fail to Visit th

LIST of EXHIBITORS

Company	Booth Number
A	
Alemite Division, Stewart Warner Corporation	101
Alliance Machine Company	147
Allis-Chalmers Manufacturing Company	38-39-40-41
Aluminum Company of America	81-82
American Air Filter Company, Inc.	98-99
American Car and Foundry Company	11-12
Amsler-Morton Company	22-23
Askania Regulator Company	64-65
Automatic Transportation Company	28-29-30-31-32
B	
Baker-Raulang Company	134-135-136
Barrett-Cravens Company	5
Bartlett-Hayward Division, Koppers Company	109
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Blaw-Knox Company	66-67
C	
A. W. Cadman Manufacturing Company	115
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D	
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Edison Storage Battery Division, Thomas A. Edison, Inc.	9
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The Iron and Steel Exposition
will be open from
9:00 A. M. till 10:00 P. M.
September 23-24-25

The Hotel Statler will be the official Convention headquarters, all social activities being held there.

IRON AND STEEL *Exposition*

CLEVELAND PUBLIC AUDITORIUM

CLEVELAND - OHIO

SEPTEMBER 23-24-25, 1941

The annual Iron and Steel Exposition which will be held in conjunction with the Annual Convention of this Society promises to be of considerable interest to all the steel mill executives and operating men. Approximately 100 manufacturers of steel mill equipment will utilize 25,000 square feet of space in the exhibit halls to display their latest designs of equipment. From advance information, this Iron and Steel Exposition will be one which few steel men can afford to miss.

EXPOSITION HOURS

- **TUESDAY—SEPTEMBER 23—9:00 A. M. to 10:00 P. M.**
- **WEDNESDAY—SEPTEMBER 24—9:00 A. M. to 10:00 P. M.**
- **THURSDAY—SEPTEMBER 25—9:00 A. M. to 10:00 P. M.**

Premixed Combustion of GASEOUS FUEL for Steel Finishing Operations

By E. B. Dunkak, Vice President
THE C. M. KEMP MANUFACTURING CO.
BALTIMORE, MARYLAND

Presented before A. I. S. E. PHILADELPHIA SECTION
February 1, 1941

▲ PREMIXED COMBUSTION is a generic term applied to the burning of gaseous fuels wherein the fuel is prepared for combustion apart from the furnace by admixture with predetermined quantities of combustion air, generally all the air necessary to produce the flame operation in question, the air and gas then being homogeneously premixed and compressed so that the combustible mixture is distributed under pressure to the appliances for consumption. The combustible air-gas mixture available for instant heat liberation is tapped from the mixture main in a manner that can be best likened to the availability of water from a service line. Here is stored heat prepared elsewhere by an automatically functioning unit instantly available and susceptible to all niceties of control.

The advantages of this method of fuel preparation are apparent to all who have struggled with the dual job of preparing fuel for combustion and liberating the heat of this combustion with the same mechanism. The result is inevitably a compromise between the limitations imposed by the method of fuel preparation and the heating requirements of the process in question. Premixing, in divorcing the problems of air-gas ratio control, turn-down range, and uniformity in air-gas mixture stream from the actual dictates of the heat application, makes possible burner applications engineered solely from the standpoint of the product—applications designed to liberate heat, controlled to a nicety as to input and composition, in its most usable form—dictated by the requirements of product as well as the striven-for thermal efficiency. Contrast this with the compromise between ability to perform and the actual requirements—so familiar to the combustion engineer—and too frequently accepted as inevitable. It may be well at this point to elaborate on the advantages that premixing brings to combustion in general. Later we will show specific results of these advantages in a variety of steel mill heating operations.

Premixing provides accuracy of air to fuel-gas proportioning over the widest conceivable operating range; this because the appliance wherein combustion takes place but indirectly affects the device proportioning air and gas. The furnace or similar appliance can operate through the widest range of heat demand by automatic or manual means; but as its heat source is merely a tap on the mixture main, the premixing unit or units supplying one or a number of furnaces, floating on the line, responds unhesitatingly to the greater or lessened demand, without change in result. Thus, constant combustion characteristics and fuel products analysis is maintained.

The flame characteristics of premixed combustion differ markedly from other forms owing to the rapid

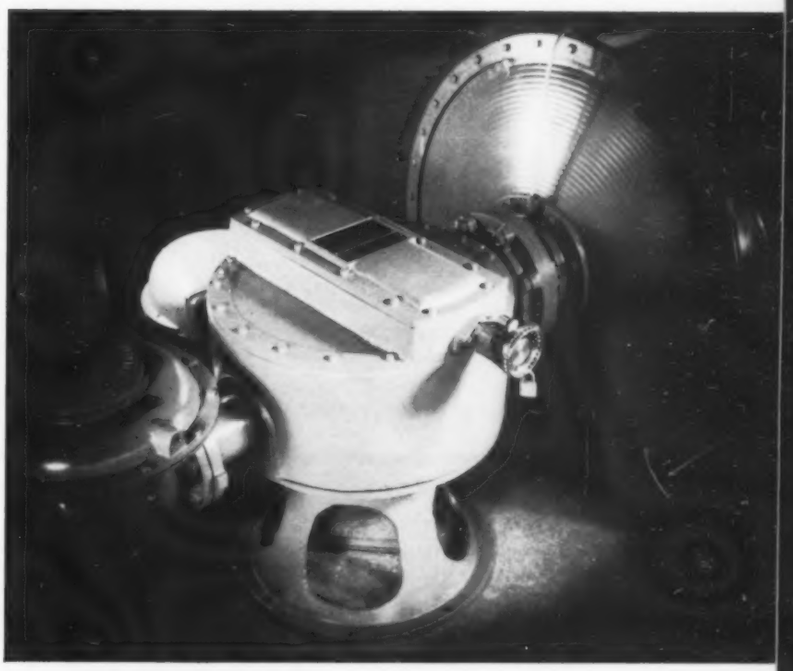
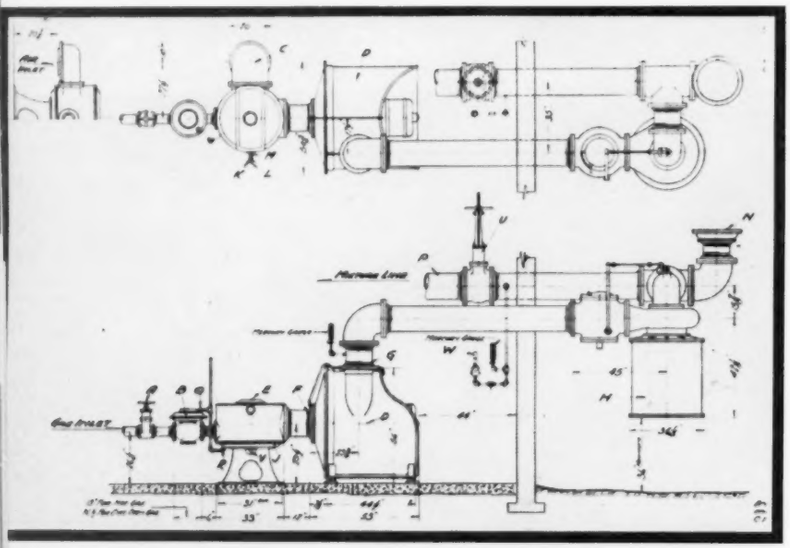


Figure 1—General view of modern premixing unit.

release of heat effected by the homogeneous mixing of air and gas, which mixing essentially surrounds each molecule of bombustible with its requisite quantity of air. A familiar illustration of this effectiveness of homogeneous mixing lies in submerged combustion, where a premixed flame burns directly in contact with a low temperature solution—and burns to complete combustion without formation of carbon monoxide or the aldehydes of incomplete combustion. The practical effect of this is the assurance of complete burning of fuel before contact with work, cold side walls, or other factors which in themselves retard combustion.

Premixed combustion is combustion with positive pressure of air-gas stream and, consequently, positive

Figure 2—Sketch showing principles of modern premixing unit.



flame pressure. This, combined with homogeneous mixing, results in high flame velocity, advantage of which can be taken in heat application to secure uniformity of distribution through rapid movement of products of combustion and constant recirculation of furnace atmosphere. When the advantages of high velocity and rapid heat liberation are combined in the form of restricted combustion space—high thermal head of both gases and incandescent walls contribute to high heating rate. In specific application, such as recirculating radiator heating, high gas velocities contribute to uniformity of tube wall temperature and low ultimate gradient between work and exiting gases; in short—effective heating with high thermal efficiency.

HOW PREMIXING EQUIPMENT FUNCTIONS

Premixing equipment in various forms has been commercially available for approximately 30 years. Like many industrial devices, its initial acceptance was slow and suffered from lack of true realization on the part of both builder and user of the economic advantages which premixing could bring to gaseous fuel combustion. As industry awakened to the possibilities of increased output and yield, through both combustion and temperature control, its use has increased immeasurably; and, during the past ten years has gained recognition as a major tool in heat utilization.

To best understand the functioning of a modern premixing unit, a glance toward the past may be helpful: By 1915 or thereabout a few premix units had been

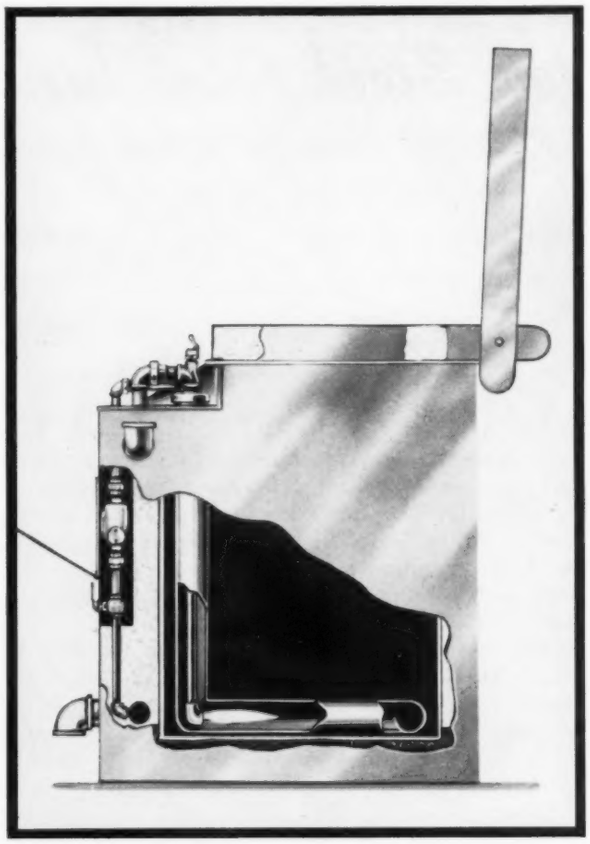


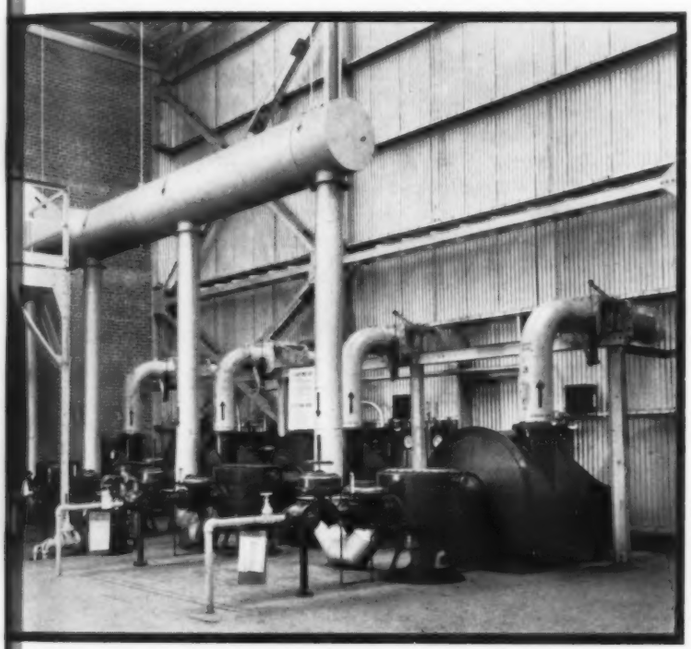
Figure 3—Sectional view of typical immersion heated unit.

built—primarily designed to supply heat for what was then considered one of the few types of heat applications requiring controlled combustion—the automatic side-seaming of tin cans. These early units functioned by alternately entraining atmospheric air and gas, the latter from a weighted gasometer, with subsequent compression. Diffusion was obtained in a reservoir tank. The mixture next passed through an early form of backfire preventor and non-automatic fire arrestors and on to the burners for utilization. For their period, they did a good job—but what is more important, they started industry in no small measure to think about improved heating application; and, when industry was ready, premixing equipment, having been continuously developed over the years, likewise was at hand. A modern premixing unit is shown in Figure 1.

Figure 2 shows the same equipment diagrammatically. Gas from the meter flows through pipe and valve (*A*) to the inlet deadweight regulator (*B*) which has been

set to discharge at approximately 1½ in. water column pressure. Air is drawn through the air filter entering at check valve (*C*). The air and gas under suction from the turbo-compressor (*D*) are drawn in unison through the proportioning valve located under the cover (*E*) to the turbo-compressor inlet (*F*). Here the air and gas are thoroughly mixed and boosted to a positive pressure. The operating diaphragm (*J*) of the proportioning mechanism raises or lowers automatically in accordance with the demand for air-gas mixture, and by so doing

Figure 4—Premixing unit serving battery of 28 tin pots.



opens or closes the proportioning valve so that the volume of air-gas mixture, always in predetermined ratio, is sufficient to meet the demand. The ratio of air to gas is manually set by hand wheel (*K*), normally locked into place by lock (*L*). The position of this hand wheel, when once set, need only be varied when it is desired to obtain a change in air-gas ratio. Counter (*M*) furnishes indication of air-gas settings made.

The gas regulator, proportioning mechanism, and turbo-compressor are located inside the buildings. The backfire preventor (*H*) and soft heads (*N*) are located outside the building, or, if located inside the building—in a protected area.

The safety devices which have been developed for premixed combustion are worthy of consideration because a proper application of premixed combustion demands full consideration of safety factors. Premixing starts out to create the most combustible mixture of fuel that can be created with cold air and cold gas. Thus, the need for safeguarding lines against precombustion is obvious. Adequate safety devices, meeting the requirements of the Underwriters' Laboratories, the effectiveness of which have been proved in hundreds of installations, are commercially available. These safeguards are in general of the three following types:

(1) Protection of individual burner or a group of adjacent burners. This comprises an automatic flame arrestor installed in the branch line supplying a burner or a closely adjacent group of burners. In the event of a backfire through one or more of these, the flame arrestor, holding the flame on its safety screen, releases a spring-loaded valve on its inlet side, cutting off flow.

(2) Soft heads, friable discs of zinc or similar easily rupturable materials, designed to release in the event of pressures higher than normal, are usually located at the end of mixture mains and serve as a non-automatic secondary protection in relieving excessive pressure.

(3) The main line backfire preventor, located at the discharge side of the central premixing unit, combines the friable pressure release of the soft head with the safety screens of the flame arrestor in a heavy construction suitable for safeguarding the premixing equipment against combustion and resultant explosive pressures in large diameter, long length mains.

Air-gas mixture from the premixing unit enters the backfire preventor through spring-loaded inlet valve held off its seat by the trigger, rod, and fuse arrangement shown, the mixture flowing into the body of the backfire preventor, through the laminated flame arresting inserts, and out through the central discharge pipe. In the event of combustion in the main, in which heat without appreciable pressure is generated, the fuse shown near the friable bottom melts, permitting the spring-loaded valve to close. If the combustion is accompanied by an expansion of gases, sufficient to crate a higher than normal pressure, the friable bottom ruptures, permitting a similar valve action.

These devices and variations of same make premixing an entirely safe form of fuel utilization. In fact, through the utilization of these devices, premixing can be considered safer than many unguarded combustion systems that make possible inadvertent admixtures of air and gas in supply lines that should normally carry but one fluid.

Premixing units are available in a wide range of sizes. Some units are installed to meet the specific requirements of a low heat consuming but quality important job—wherein the total Btu. consumption may be no more than 100,000 per hr., and where the unit is operated by a ¼ hp. motor. From this, installations range in all sizes to batteries of steel mill units having capacities to utilize 50,000,000 Btu. or more per hr.

APPLICATIONS AND ADVANTAGES

Premixed combustion can be best appreciated by a study of applications wherein, through widespread adoption, efficiency and economy have been established. This is particularly evident in the principle of immersion heating; that is, the heating of solutions, easily fusible metals, and salts by immersed, hollow heating elements in which premixed combustion takes place and heat is liberated and transferred. Premixing has made immersion heating practical, for only by this method can be obtained the requirements of controlled flame size, rapid combustion, accurate maintenance of air-gas ratio under wide operating range, and high flue gas velocity.

The economy of immersion heating rests on three

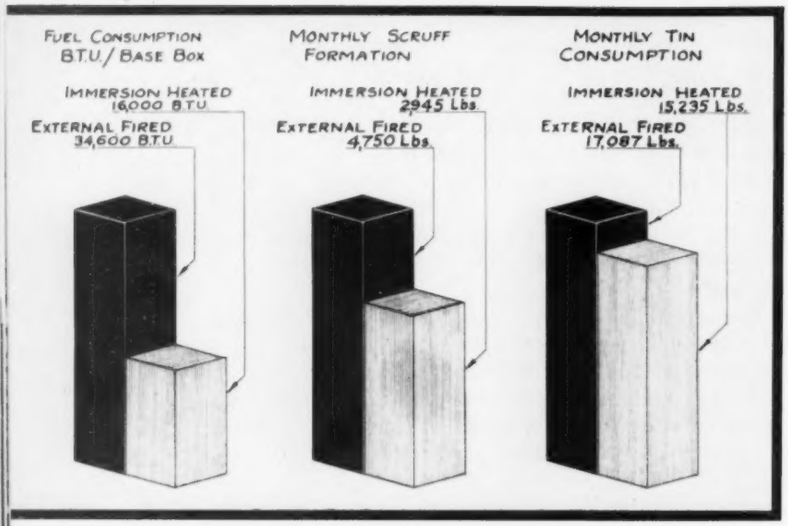


Figure 5—Graphical presentation of tin pot performance data.

principle reasons, all of which are reflections of premixing. These are:

(1) Economy of fuel through applying heat internally in place of externally, with resultant lowered flue gas temperature and decreased losses to the setting. The internal application makes possible adequate heating surface—for the first time heating surface is predicted by the requirements of a specific job rather than the exposed surface of the container holding the molten metal. Further fuel economy is effected by close control of air-gas ratio so that combustion, regardless of combustion rate, always takes place to produce maximum CO_2.

(2) Close regulation of temperature—an outstanding feature of immersion heating, is the result of a heat application where there is virtually no heat storage to give temperature over-run or lag. But, again, without premixing, the wide turn-down range essential to prevent overheating when idling, in what is substantially a thermos bottle setting, coupled with high connected load to assure rapid response to productive demand could not be otherwise obtained.

(3) Dross formation is materially reduced in many operations by utilizing the substantially inert products of combustion—substantially inert only because they are prepared by premixing to blanket the exposed metal surface and thus exclude the oxidation normally encountered through atmospheric contact.

Figure 3 shows a sectional view of a typical immersion heated unit.

With these principles in mind, let us examine a few typical applications of immersion heating to steel mill practice. The coating of tin and terne plate in immersion heated pots dates from 1930 when, through the coöperation of the then American Sheet and Tin Plate Company, the first commercial installation of an immersion heated tin pot was made, this being a trial unit installed at Monessen Works. This installation, although of a design that today would be considered crude, displayed certain potentialities and, as a result, when soon afterwards the Monessen Works was rebuilt, it incorporated the pioneer installation of fourteen tin stacks. Since that time the same principle has been adopted by almost all of the producers in the United States and many producers abroad, so that today it is conservatively estimated that more than one-half of the world's tin plate is produced in premixed fired immersion heated pots. Typical of this is the installation in one of the newer mills, where a battery of 28 pots is fueled by the premixing installation shown in Figure 4.

The reason why the industry has so widely adopted this method of heating in a period of ten years is most clearly brought out by the data tabulated below, this having been abstracted from "before" and "after" rests in a prominent steel mill.

	External heating	*Immersion heating*
Duration	8 weeks	8 weeks
Gas used, M cu. ft.	2,459	1,130
Cost	$182.68	$83.78
Gross fuel savings	....	$98.90
Total base boxes	22,512	22,259
Metal used, lb.	37,903	34,239
Scruff, lb.	8,940	5,975

An analysis of this test data showed that the savings per base box produced, immersion fired over external fired, totaled $.02937—which saving is a combination of the savings through metal recovery, reduced scruff reclaiming operation, reduced fuel consumption, and an arbitrary but moderate allowance for reduced pot maintenance through elimination of external settings. Figure 5 illustrates this analysis of savings graphically.

With a monthly production of 10,500 base boxes, the total annual saving showed a return of more than 150 per cent on the required investment; and on this basis the installation was made. But far beyond all this, what

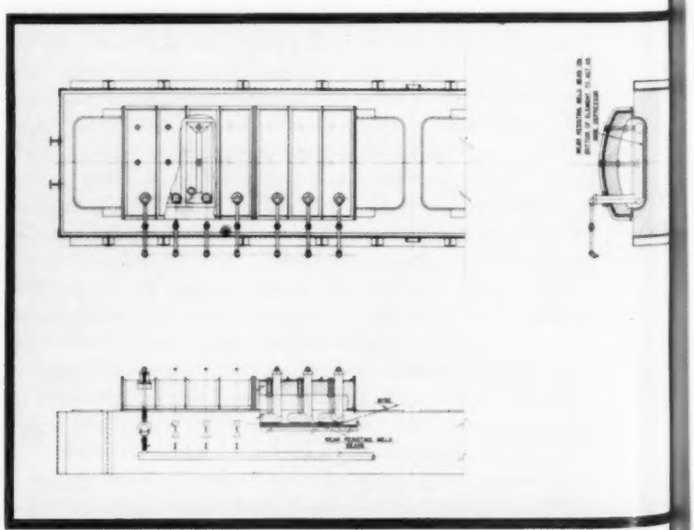


Figure 6—Typical installation of immersion heating to lead pan annealing furnace.

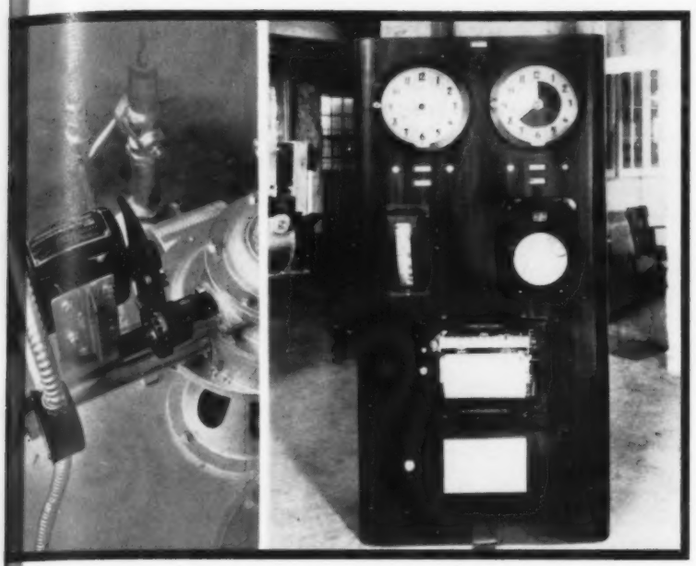


Figure 7—Conditioned gas may be constantly analyzed for hydrogen content.

actually happened when the installation was in service was a demonstration of increased production, for no longer was the heating method the bottle neck, with the result that today production per tin pot through the industry is on an average basis increasing, and, with new installations now planned and under the course of construction, a further increase will take place. So, hand in hand with economy in production, we find premixing making good its claims for increased production; and still the good results do not stop here. Recently, experimental work on quality of tin plate has shown the need for what is virtually absolute control of temperature of the palm oil bath through which the tin plate exits. Development work on palm oil temperatures indicates that temperature variations of as little as plus or minus 2 degrees F. have an effect on the quality of the coating. As the palm oil is heated by contact with the molten tin, and the tinned plate, it is apparent that any heating system which lends itself to extreme accuracy of control will help to minimize variations in palm oil temperature. Through the use of the proper temperature controlling systems, it is now possible to hold variations in palm oil to less than plus or minus 1 degree F., and units are being so operated on a commercial basis.

An example of immersion heating at higher temperatures is the hot lead pan for wire annealing. Particularly noteworthy is the method of using the immersion elements as "sinkers" for the wire and an insulated cover which serves the dual purpose of minimizing surface radiation while holding the products of combustion against the surface of the molten lead. Performance on one such installation shows the following:

(1) Fuel consumption reduced 55 per cent over external practice.

(2) Temperatures controlled within plus or minus 3 degrees F. when operating at 1380 degrees F.

A typical arrangement (dual pan—first for preheat, second for soak) is suitable for a production in the neighborhood of 9000 lb. per hr. The total connected load is in the neighborhood of 4,000,000 Btu., and the Btu. consumption per net ton produced when processing at 1380 degrees F. is 765,000.

The bluing of steel strip in an immersion heated lead bath typifies an application wherein the unique ability of the premixed fired immersion element to liberate heat in the space desired is most pronounced. The cold strip, in entering, extracts from the front end of the pot virtually all of the heat required to raise it to the bluing temperature. With immersion heating it is possible to design for this condition, placing the maximum of heat transfer surface in the shortest possible distance, tapering out the input as the heat demand decreases. With this type of application, it is possible to install several times as much high rate heat transfer surface as would be the case were walls of pot alone used, and in so doing operate a smaller unit with higher thermal efficiency.

Figure 6 shows such a unit. Here we have a 9 ft. long lead bath suitable for material having a maximum width of 24 in. Connected load is 750,000 Btu. per hr. and the pot is suitable for processing 4500 lb. per hr. at temperatures up to 1000 degrees F.

So much for the immersion heating principle made possible by premixing. Now let us consider another field where the accuracy of proportioning obtained by

Figure 8—Premixed firing is used in this portable annealing cover.

premixing has proved to be of paramount importance. I refer to conditioned gas for deoxidized annealing.

The heart of the gas conditioning unit is the device that proportions fuel gas to air. For, while other factors such as combustion chamber design, combustion chamber temperature, and final dewpoint of conditioned gas materially affect the usefulness of the output, regardless of combustion chamber temperatures, conditioned gas stability, and dewpoint, the best design and the best operation goes for naught if the fuel gas and air are not being proportioned properly with the subsequent homogeneous mixing to assure not only the proper ratio of combustion—but combustion free from stratification. This prohibits the passage through the combustion chamber of uncombined fuel and uncombined oxygen. A truly satisfactory gas conditioning unit should be able to float on the line, automatically responding, over a reasonably wide range of say 30 to 100 per cent of capacity, to changes in demand without changes in composition. The most accurate proportioning device

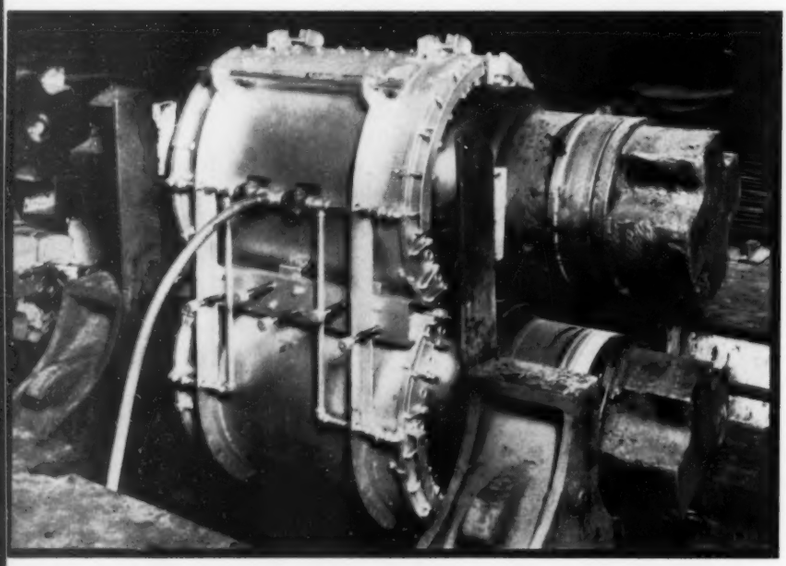


Figure 9—This roll heater, containing tubular heating elements, uses premixed firing.

is not any better than is required for this exacting service.

In atmosphere gas work, the premixing unit can be controlled to produce virtually constant conditioned gas analysis by taking advantage of its inherent simplicity in changing proportions of fuel gas and air at will. Many plant installations working 24 hr. a day, 7 days a week, do not lend themselves to the maintenance that equipment operating to give precision results requires. And, when this condition is coupled with a dirt-contaminated plant atmosphere or changing composition, specific gravity, and thermal value of fuel gas, truly constant conditions can only be obtained by means of control of proportions from resultant conditioned gas analysis. For this purpose a supplementary control has been developed, a monitor which constantly analyzes the conditioned gas for hydrogen content through the thermal conductivity of the sample. The result of this analysis, transmitted through a potentiometer and a controlling circuit, readjusts the position of the proportioning hand wheel of the premixing unit in accordance with the changes required, and thus restores and maintains the desired analysis of conditioned gas.

The monitor controlling a gas conditioning unit is shown in Figure 7. It is an extremely sensitive device, ½ in. of the scale being approximately the equivalent of 1 per cent hydrogen by volume. In one mill having a number of these units, routine checks with an Orsat for CO_2 concentration show that the monitor holds the CO_2 content, which bears a direct relation to H_2 content, within plus or minus 1/10 of 1 per cent, which, incidentally, is well within the accuracy of the checking instrument.

Premixing has demonstrated its advantages very definitely for indirect heating when utilized in conjunction with the continuous recirculatory radiator. This radiator constantly recirculates large volumes of products of combustion, the recirculation being effected by the high velocity premixed flame. This flame, of extremely low luminosity, and of controlled diameter, is positioned to project down the center of the tube, injecting spent products of combustion with it, thus tempering the flame and giving a radiator having the unusual characteristics of uniform temperatures from end to end. Such radiators operate with a slightly positive pressure and thus are unaffected by overventilation when the burners are in the throttled position.

Figure 8 shows an annealing cover utilizing premixed firing and recirculating radiators. These annealing covers have set the pace for fuel rate in the industry; and, because the premixed combustion lends itself to throttling control, unusually satisfactory annealing temperature curves can be secured.

Where it is necessary to liberate small amounts of gas in a large number of places with controlled combustion, premixing is pre-eminent because of the complete separation of proportioning from combustion. The roll heater utilizing tubes for heat transfer, shown in Figure 9, is an example of this. Here is a unit that requires for its successful operation controlled combustion in 72 places, the combined Btu. liberation not totaling more than one-quarter million. Premixing with its single mixture connection to this portable equipment assures, after simple flashing from an ignition torch, continued, stable operation with either automatic or manual control, the latter, obtained through a single index valve, being simplicity in itself.

CONCLUSION

This concludes the specific examples of premixing in the steel industry, although by no means does it cover the full range of its application. All of the examples shown help us to realize the inherent advantages and economies of premixing, which can be summarized as:

(1) Central proportioning independent of burner application.

(2) Combustion under positive pressure with maximum Btu. release.

(3) Control of air-gas ratio and resultant combustion

within the dictates of the application, no matter how intolerant.

(4) High velocity of flame and products of combustion.

It is the opinion of those who are close to this work that the field of application for premixing in the steel industry is considerably wider than that which has been developed to date; and this opinion is shared by the author. In considering the future, it is, however, important to recall that many of the ideas and most of the developments referred to in this paper came into being only through the interest and coöperation of progressively minded engineers, particularly those making fuel their major work. Thus, as time goes on and the men of your industry think more in terms of what premixing may do, we can look forward to additional premix applications in a wide range of heating operations. Suggesting themselves as problems to be faced in the immediate future are:

(a) Galvanizing through the immersion principle with materials suitable to withstand the ever present alloying action.

(b) The direct firing of annealing covers utilizing the velocity advantages of premixing to secure both high rates of transfer and uniformity of distribution.

(c) The dilution of high Btu. gases for soaking pit firing.

Doubtless other potential applications suggest themselves; and, as the history of premix applications has been one of constant experimentation and development, your industry can be assured that engineers engaged in this work welcome the opportunity which these problems will present.

DISCUSSION

PRESENTED BY

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G. O. VAN ARTSDALEN, *Superintendent of Maintenance,* Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

H. C. SIEBERT: There are one or two questions I might ask Mr. Dunkak. I didn't notice in the paper any mention about the gases being desulphurized. You said the dew point is controlled, but you didn't say anything about sulphur content, did you?

E. B. DUNKAK: We consider desulphurizing one of the steps in gas preparation, prior to combustion.

H. C. SIEBERT: Another thing about immersed heating, for example, in pickling tanks; you are familiar with large tanks, wood or rubber or brick-lined. Usually the steam condenses in the liquid, which is rather wasteful in acid. Now in immersion heating is the gas exhausted through vents, or is it allowed to bubble up through the solution? Immersion heating as against the steam heating of the solution has come up and has been discussed by several of our engineers and the question arose as to whether this has been done. I think one of our men found that one of the motor industries found that the gas bubbling through the solution made the process unsatisfactory, and they went back to the steam heating of the solution, by the old method of steam piping.

That is all I have in mind. I think the paper was very interesting although I was rather put up in the stratosphere by Mr. Dunkak's claims of accuracy. Those claims of accuracy seem to me to be beyond the commercial requirements.

Also, for annealing furnaces, it is interesting to note that he mentioned high heat transfer efficiencies. Are they due to high velocity? They were termed high, but no figures were specified.

E. B. DUNKAK: Mr. Siebert asked a question regarding the possibilities of combustion below the surface of the solution for the heating of pickling tanks.

In the combustion application wherein the products of combustion are liberated into the solution, the term "submerged combustion" is generally applied as contrasted with "immersion heating," which is the method of burning inside a tubular structure without venting the products of combustion into the solution.

The submerged combustion process is the one which Mr. Siebert has in mind. This process has some merit. It is efficient for solution heating at temperatures up to perhaps 150 degrees F., and it is excellent for many of the concentrating operations carried on in the chemical industry; but as the pickling operation calls for temperatures of 210 degrees F. or thereabout, the thermal efficiency of submerged combustion is virtually nil when so applied—this because of the moisture carried away by the products of combustion as they come up through the solution. The heat removed by the saturated products of combustion is such that there is virtually a heat balance at 195 degrees F.

Mr. Siebert raises another question with regard to

heat transfer. The claim that we make for the recirculating radiator with the premixed flame is a high rate of heat transfer under the immersion condition where the heat transfer capacity of the fluid in which the element is immersed is almost infinite as far as extracting heat from element surface is concerned; in any event, far greater than the heat transmitted by the gases to the inner wall of the element; consequently, the higher efficiency for the recirculating radiator when performing an immersion heating operation. But, if we talk of this in terms of the annealing furnace, where heat is largely transmitted by radiation, the premixed-fired tube would not have a higher rate of heat transfer than any other tube for a given surface temperature.

M. J. BOHO: Mr. Dunkak has done an excellent job and is to be congratulated for taking up a combustion idea and developing it to the point where the accuracy of the results obtained is measured in terms of three or four decimal places. I doubt if such accuracy can be obtained in the regulation of open flames, such as commonly used in slab heating furnaces and soaking pits where orifices are used and the differential pressures across these orifices are balanced against each other to control air to fuel or vice versa. It happens that these differential pressures vary as the square of the rate of flow and, as the firing rate decreases, these differential pressures decrease very much faster so that at low firing rates the pressure differences drop to such small values that the problem of sensing them becomes a very important factor.

With Mr. Dunkak's scheme, he uses in effect the same pressure difference on both gas and air orifices since both orifices open directly to the mixing exhauster. This reduces the problem of accurate control to a problem of accurate adjustment of areas, which can easily be done by experiment.

The significant factor that would account for the perfection of combustion which Mr. Dunkak reports is the thorough mixing of air and fuel that is obtained when passing through the blower or mixer. This, of course, has no parallel where open flames are controlled, and mixing accomplished simply by the turbulence of the burner.

Fortunately for us, the application field of the premixed process is not as wide as it might be and there are still fields in which our equipment can be used where such a phenomenally high order of accuracy is not required.

H. M. SCHMITT: Controlled atmosphere gas analysis measurements of the order of magnitude mentioned by Mr. Dunkak are not normally recorded directly on instruments such as were shown in the paper. It is conceivable that components of the exit gases can be interpreted from the chart records to a high degree of accuracy after their relationships have been established. Direct measurements of certain gases, hydrogen for example, may be recorded and knowing the composition of the entering gases and the reactions which take place, the chart record may also be interpreted in terms of other gases.

W. M. CLINE, JR.: There's not much I can say about the lead pan installation, at this time. In regard to Mr. Dunkak's paper, however, I believe that he could have placed more emphasis on the importance of proper maintenance of this equipment.

The regulators, proportioning valve and back fire preventor require nothing more than periodic cleaning, say once every 6 or 8 weeks. However, too much importance cannot be placed on the regular inspection and testing of the shut-off valve and the screens in the fire checks.

We find that by properly instructing one man in the cleaning and testing of the checks, we are assured of a tight shut off of the valve, if a back fire should occur at the burner.

E. B. DUNKAK: Mr. Cline's point on maintenance is very good and is well taken. We set out to produce the most combustible mixture of air and gas—a mixture that is completely combustible of itself. The safeguards we offer with our equipment can be best compared with the safeguards used with electrical equipment. If these devices are not properly maintained, they are not going to function when called upon; but when properly maintained (and I do not mean handled with kid gloves), they will function to the degree of safety required to satisfy plant operation.

M. J. BRADLEY: If the flame maintains its position and velocity, the same under all conditions, how is local overheating prevented when starting up a cold tin pot? As I visualize the starting up operation the pressure of the premix gas should be somewhat lower until the bath becomes molten than the pressure necessary to supply the much greater heat input required during production.

Another point connected with the installation shown in the illustration—the gas volume was controlled by a pressure regulator in the gas line while the combustion air was supplied by a motor driven fan. If this combination is capable of meeting wide changes in demand, possibly from 10 to 100 per cent, how is the air volume regulated? If the motor is a constant speed motor, is there a regulating coupling between the motor and the fan? How is it possible to obtain such a wide turn down and still maintain the combustion characteristics constant?

E. B. DUNKAK: Mr. Bradley commented on Btu. release when starting up an immersion melting installation as compared with the Btu. release during its subsequent operation.

In starting up it is the usual practice to manually throttle the heat input for a short time so that the element will not be subjected to too great thermal shock. However, this is for a very short period, and long before the unit is ready for service; all control is from the automatic temperature controller, which, should it be a 2-position unit, would be wide open during most of this time.

The characteristics of premixed combustion are such that combustion takes place on the face of the burner, is supported by the burner itself, and no incandescent surfaces are required to effect complete combustion. There is no warming-up period with premixed combustion. We do vary pressure during operation, that is—effective burner pressure. This occurs every time the temperature control comes into service.

With regard to Mr. Bradley's second point, regulation

of air volume in relation to gas volume demand—this takes place automatically through the proportioning valves of the premixing unit. The motor driving the compressor is constant speed. The compressor, being self-bypassing, floats on the line automatically responding to changes in demand. The wide turndown range is made possible by the presence of the proportioning mechanism operating as it does on virtually constant differential across the proportioning orifices, the size of which vary in proportion to demand.

F. C. SCHOEN: I am interested in lead pots, and in their maintenance. That is, what increase in life can we expect in a pot with the immersion firing as against the external fire; and is it possible that the burners will go sour in the pot? If so, are they readily changed? Because if you have a pot in continuous operation and cannot change the burner, it means pulling the pot out of service.

E. B. DUNKAK: With regard to greater lead pan life with immersion heating as contrasted with external heating, and the economics of this as an offset against replacement cost of the immersion heating elements, if our chairman, Mr. Fisher, is agreeable, I would refer this question to him, because he is in a position to give us actual plant experience record.

HOWARD HALSTEAD: With regard to the life of the pan, we expect almost indefinite life—by that I would say five years, for the lead pan itself. As far as the elements go, we replace the elements probably once every four months. The elements are made of standard pipe, they are cheap to make, and we feel the fuel saving balances the cost of the elements. Roughly, I would say the cost of the elements amounts to ten per cent, approximately, of the cost of the fuel, and inasmuch as we have saved probably 50 per cent of the fuel cost, we feel justified in using the immersion firing. The lower cost in immersion firing is due to the saving of the fuel, 50 per cent, roughly, and the saving in the life of the pan.

Speaking of corrosion of the lead line, we put pipe reinforcement at the lead line and that does help the element's life.

P. C. REICHARD: Mr. Dunkak's paper is of particular interest to us in Bethlehem, since, in the modernization and extension of our heat treatment facilities, we prefer holding to the application of gaseous fuels, rather than to swing over too far towards electric heating. We regard this type of machinery with considerable interest since it makes possible efficient high rates of heat release through radiant tubes.

In order that the cost of process interruptions, and of the maintenance of the screens, safety devices and regulating equipment may not be prohibitive, it is of interest to know the degree of gas cleanliness required and how low a Btu. gas can be practically applied to these machines.

E. B. DUNKAK: In our premix combustion installations, we have used a wide variety of gases ranging from those quite low in Btu. (such as 150 Btu. anthracite producer gas) to the high Btu. liquefied petroleum gases. The majority of our installations use coke oven and natural gas as fuel. Where coke oven gas is used, we stress the desirability of its being first treated to remove as much of the fines, tars, and sulphur as it is conveniently possible to do; the point being that it is easier to treat the gas in its concentrated form before premixing. But by this I do not mean, however, that the gas will have to be treated to a point where it is chemically pure. This is a definitely not so, as evidenced by installations at Jones & Laughlin Steel Corporation, Aliquippa, Pennsylvania, Inland Steel Company, Indiana Harbor, Indiana, Great Lakes Steel Corporation, Detroit, Michigan, and Bethlehem Steel Company, Sparrows Point, Maryland.

W. N. HORKO: We have a small tempering die fired with city gas premixed in one of Mr. Dunkak's units. The die is 12 in. wide by 32 in. long by 3 in. thick with four firing tunnels running lengthwise through the die and equally spaced across the die. Four burners fire straight through and alternately in opposite directions.

When we first installed this unit, we experienced a lot of trouble with howling of the burners. This trouble was corrected by a change of burners. Then we found that the uniformity along the length of the die was not good. The ends were hot and the middle section was cold. This was corrected by placing a stainless steel tube about 8 in. long over the burner. In this way, the flame was carried farther into the die and the non-uniformity was greatly improved.

A recent check made at 2 in. intervals lengthwise and crosswise showed the temperature uniformity to be within plus or minus 15 degrees.

A. J. FISHER: Mr. Horko has brought up a very good point, and that is on certain applications these premixed burners do howl and make noises. Mr. Dunkak should explain why these noises are brought about on certain applications; I am sure with his wide experience he could elaborate on this point. However, in practically all cases that I know of, he has been able to eliminate the noise by certain adjustments.

E. B. DUNKAK: Burner noises can result from a number of inter-related causes, only some of which are recognized and understood. There has been some fundamental research and a great deal of practical experimentation; and, from the latter, we have discovered ways of correcting these noises should they develop in an installation.

There are several factors, that we know of, effecting burner noises; one is the inter-relation of the individual burner ports in a burner head, a premixed combustion burner head consisting of a tremendous number of small burner ports closely spaced. Another factor is the relation between the diameter of the flame and, in immersion heating, for example, the internal diameter of the heating element. This by no means covers all of the factors but serves to show some of the items that must be given consideration in design.

G. O. VAN ARTSDALEN: I am not a combustion man but I am mechanically minded. I was interested in a problem we have been faced with with reference to these soft heads, as Mr. Dunkak calls them. We have had several serious explosions that damaged equip-

(Please turn to page 87.)

PRECIPITRONS *for the Steel Industry*

By G. E. Stoltz, Manager

METAL WORKING ENGINEERING

WESTINGHOUSE ELECTRIC & MFG. COMPANY

EAST PITTSBURGH, PENNSYLVANIA

Presented before A. I. S. E. DETROIT DISTRICT SECTION

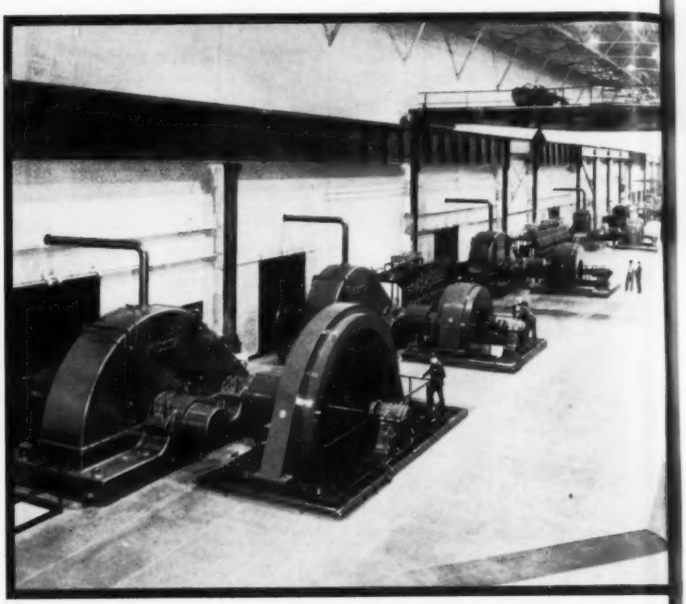
October 8, 1940

▲ THERE are several reasons why the steel plant engineer must concern himself with proper cleaning of air used in ventilating electrical equipment. The first is that the windings of a motor or generator are one of the more vulnerable parts of the machine. While the windings may be carefully impregnated when new, deterioration may take place on steel mill applications due to vibration, overheating, sweating, or bad atmospheric conditions caused by the presence of dirt. As long as the original condition of the winding is maintained, dirt may not cause the failure although its presence in the ventilating ducts may result in higher operating temperatures.

Sweating of the windings is more prevalent in steel mills than in many other industries. This is due to the fact that furnaces which are placed in operation at the beginning of the week cause rapid changes in temperature of the air around the electrical equipment. This often results in a deposition of moisture on the electrical equipment in the immediate neighborhood. On large equipment, heaters are often placed underneath the machine so that its temperature can be maintained at a slightly higher value than the surrounding air. This prevents the machine from sweating.

Electrostatic Air Cleaner Applications

Company	Service	Cu. ft. per min.
Weirton Steel Co.	Tandem cold reduction mill	144,000
	Three skin pass mills	3×45,000
	Skin pass mill	26,000
	Hot strip mill	432,000
	Pickling line motor-generator and control room	9,000
	Steel plant laboratory	16,000
Wheeling Steel Corp.	Tandem cold reduction mill	160,000
	Skin pass mill	15,000
	Hot strip mill (make-up air)	120,000
	Office building ventilation	13,500
Aluminum Co. of America	Reversing aluminum plate mill	72,000
	Aluminum strip mill	27,000
Bethlehem Steel Corp.	Rotary converter substation	20,000
	Bar mill (make-up air)	12,500
	Office building ventilation	56,000 40,000 10,000
Inland Steel Co.	Office and drawing room ventilation	22,000 16,000
	Scarfing machine smoke elimination	36,000
Acme Steel Co.	Cold strip mill (make-up air)	2,400
Jones & Laughlin Steel Corp.	Cold strip mill control balcony	4,800
Innis-Speiden Co.	Electro-chemical rotary converter substation	40,000



Modern motor rooms are usually ventilated by a recirculating forced draft system.

Mechanical vibration and sweating of the windings may cause either a break or a deterioration in the varnish used to impregnate the windings. Either may allow the creeping of dirt into the winding sufficient to eventually cause a ground or a short circuit.

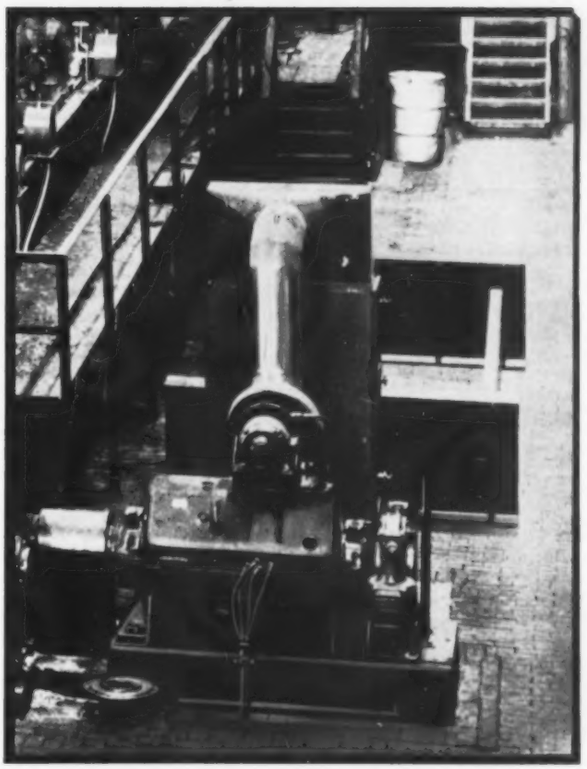
Another reason which makes the presence of dirt in the steel industry more hazardous than in other industries is the fact that a very large percentage of the dirt is conducting. Some years ago we made an analysis of a sample of dirt collected on the bedplate of the motor and found that 85 per cent of it was either carbon or metallic dust, both of which are highly conductive. This means that grounds or short circuits will occur much more readily in the steel industry than in indus-

tries where these faults are caused by other types of dirt. It is not unusual to find a motor in the cement industry that is thoroughly covered with cement dust, but it may operate for years before a failure occurs, due to the fact that lime is not a conducting material.

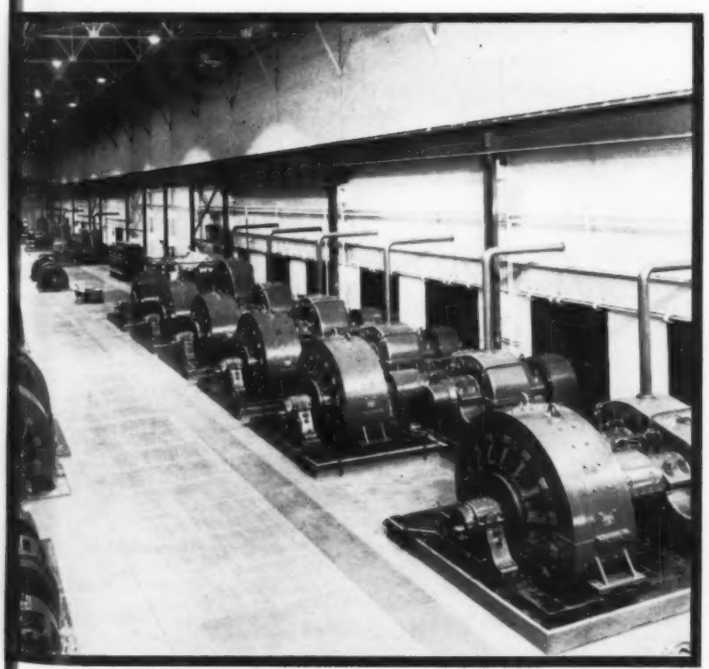
Another factor to be considered in the steel industry is the importance of maintaining the continuity of certain operations. Many of the manufacturing processes in a steel plant are straight line production and the failure of one motor may mean the interruption of considerable machinery, so that extra precautions may be justified.

Whether or not a machine is ventilated with clean air depends upon several conditions. One is the operating value of the machine itself as well as its importance to the operation of the equipment it drives. Motors on large mills may have a rating of several thousand horsepower and while they may be installed in a motor room that isolates them from the mill, unless there is a ventilating system present which raises the pressure in the room above the surrounding air, scale from the metal rolled will sift into the motor room and into the windings of the machine.

Motors of this capacity applied on a large mill are usually selected with considerable care and their performance is under the supervision of skilled operators. There is not a great deal of likelihood of such motors being overloaded to an extent where the windings will be damaged, and their continuity of service depends largely upon maintaining good atmospheric conditions in the air used for ventilation. For this reason it is sometimes possible to justify the installation of cleaning equipment to keep the dirt away from the windings.



View of electrostatic cleaning unit applied on an important isolated auxiliary drive.



Air cleaning equipment gives little added cost in installations using artificial ventilating systems.

There are a number of applications of large motors particularly on cold strip mills as well as on reversing blooming mills where the motors are required to carry full load current at very slow speeds. Under this condition artificial ventilation is required to insure the proper air supply when the motor is turning over at a very slow speed. When artificial ventilation is introduced air cleaning equipment can be added at very little increase in cost.

Another item that influences whether or not clean air is provided is the grouping of the electrical equipment. On tandem mills of various kinds there may be a concentration of a large amount of electrical equipment in a relatively small space so that artificial ventilation and cleaning of air is not an expensive problem.

Another factor of course is the amount of dirt in the atmosphere. Those locations near a blast furnace, open hearth, or a large mill where scale from the metal is thrown into the air subject the motor to considerable dirt, while in certain finishing departments this presence of carbon and metallic dust may not be so prevalent.

There are two general systems of ventilating electrical equipment in the steel industry; one being the recirculating and the other the through system. Where there are a number of motors or motor generator sets installed in one room, it is practice to draw air down through the electrical equipment, through an air cooler and a blower, and then return the air to the motor room. This provides cool air in the motor room for the operator. In addition to the blowing equipment required to recirculate the air it is customary to provide a make-up

fan which adds from 10 to 20 per cent new air into this system. This compensates for leaks in the motor room and maintains a pressure above the surrounding atmosphere so that any leakage will be out of the room instead of in. The make-up blower is usually provided with a filter.

Where a single motor is to be ventilated a recirculating system may consist only of a blower and cooler that will be mounted in the motor pit and the air is drawn out of the motor through the cooler and blower and then returned to either one or both ends of the machine. If the machine happens to be a direct current motor it may be practical to introduce an electrical precipitator in this system in order to take the carbon from the brushes, which would otherwise deposit on the windings of the motor, out of the air.

Through ventilating systems usually bring air from the outside from as clean a location as is possible. It is customary to provide a filter so that clean air is used.

In the past it has been customary to provide mechanical filters although in the last year over a million cubic feet per minute of precipitators have been installed. They have a distinct advantage over the mechanical filter as they are effective in removing the small particles of dirt which the mechanical filter cannot catch. This is very important as it is the fine dirt that works into the winding of the machine and causes ultimate failure.

The precipitators are installed in banks so that the plates can be easily washed. Troughs are placed in the floor at both sides to drain the wash water away. Depending on the amount of dirt in the atmosphere, it is necessary to wash the precipitators every several weeks and to spray the plates with oil to hold the dirt. If this maintenance is provided, the precipitator is a very effective means of protecting electric machines from dirt.

DISCUSSION

PRESENTED BY

J. L. BUELL, JR., *District Manager*, Reliance Electric and Engineering Company, Detroit, Michigan

G. E. STOLTZ, *Manager*, Metal Working Engineering, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

A. J. F. MacQUEEN, *Superintendent of Maintenance*, Rotary Electric Steel Company, Detroit, Michigan

G. F. BEGOON, *Manager of Precipitron Sales Department*, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

R. M. HUGHES, *Assistant Chief Engineer*, Great Lakes Steel Corporation, Ecorse, Michigan

J. L. BUELL, JR.: I would like to know how you wash these units down. You have to have an oil film on them.

G. E. STOLTZ: On large industrial installations a semi-automatic means can be installed with the precipitator units to first wash the ionizing chamber and plate assembly then dry the plates and following this nozzles can be provided to spray oil on the plates.

I have a room unit in one of my bedrooms that I use during the fall, winter and spring season. Since this is a small unit I simply remove the de-ionizing and plate assembly from the unit and carry it into the yard where I wash it out with a garden hose. This is done approximately every three weeks and while I should spray oil on the plates to hold the dirt, I have not done this for a number of years due to the fact there is some oil vapor in Pittsburgh atmosphere which seems to be sufficient to hold the dirt on the plate.

Where hot air systems are used for home heating, it is customary to install the precipitator in the cold air intake to the furnace. The design is usually such that the electrical connections are removed when the inspection door is opened. Drains are provided so that the plates can be washed by merely turning the hose on without removing the units.

A. J. F. MACQUEEN: Is it possible to remove odors with these units?

G. F. BEGOON: No, we can't make any positive scientific statement about removal of odors. We have a number of installations in night clubs. In such places the advantage of a precipitator is that by precipitation the smoke is taken out of the air, so that they can cut the amount of fresh air that is required by 50 per cent. In some of the installations the users tell us they have some odor correction too.

A. J. F. MACQUEEN: That comes through the precipitator?

G. F. BEGOON: Apparently there are gases that affect the sense of smell, but they are gases. They are not particles such as you can charge and remove electrostatically. Ozone may mask it out, it may neutralize it, or the odor is probably still there but the ozone is neutralizing it so that it does not affect our sense of smell in the same way.

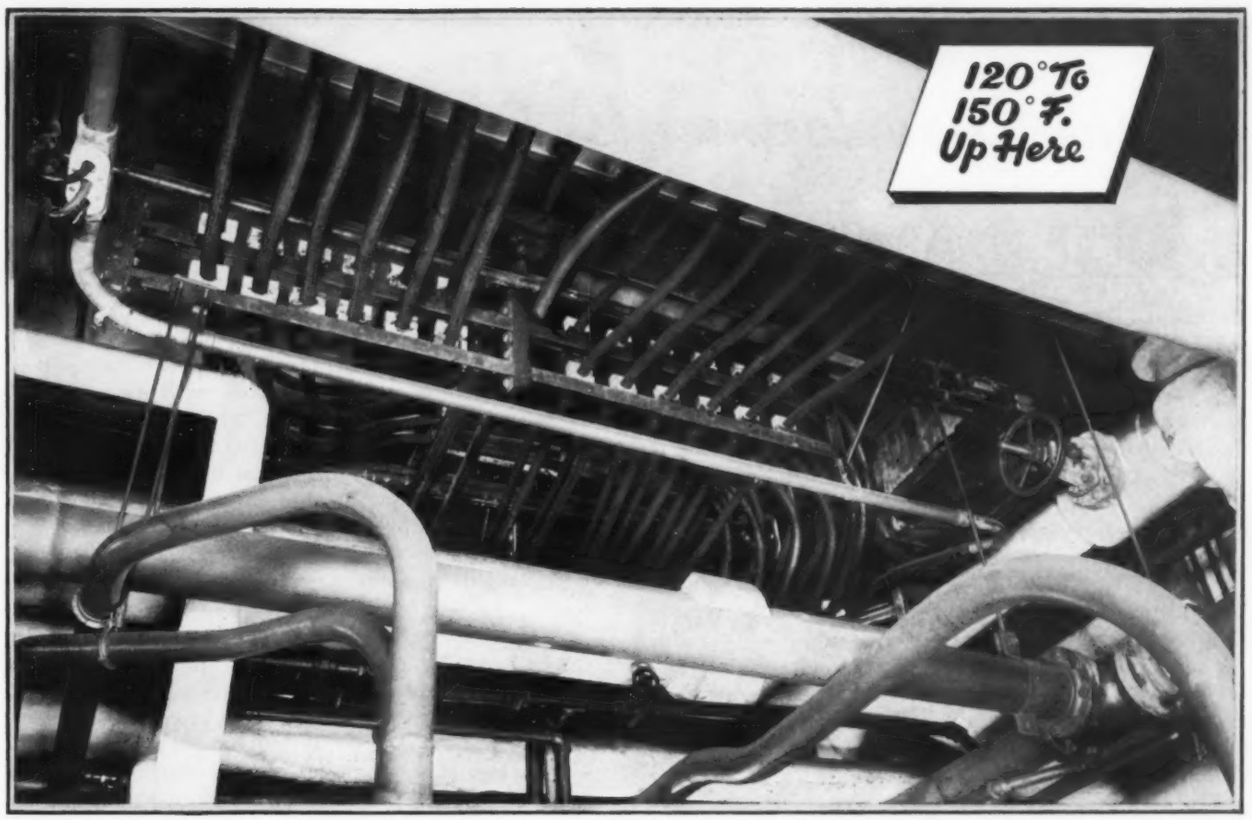
R. M. HUGHES: Are you using this mechanism at blast furnaces to clean gases?

G. F. BEGOON: The newest thing is the application at Inland Steel, a 30,000 cu. ft. per min. unit to take care of smoke coming from a scarfing machine and it is doing a fine job. Blast furnace gas is a wet gas. If it condenses too much moisture on your coils, you lose your voltage and therefore your efficiency.

A. J. F. MACQUEEN: Another thing that is puzzling me about this air cleaning for motors in steel mills: Just what sort of yardstick do you use? Just how do you determine when it is economical to install cleaning equipment?

G. E. STOLTZ: Mr. MacQueen's question is a fair one but I am sorry that I cannot answer him definitely as the determination whether air filter equipment is installed has largely been the matter of experience. We know from previous installations of a similar character

(*Please turn to page 87.*)



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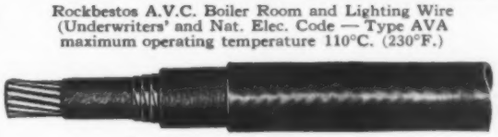

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Recent Developments in

SALT BATH FURNACE PRACTICE

▲ THE use of salt baths for heat treating purposes is quite old—probably fifty years old. In its simplest and earliest form, known as a pot type furnace, it was heated by gas or oil. The pot containing the salt is placed within a combustion chamber, and the heat, absorbed by the pot, which is usually made of cast steel or heat resisting alloy, is conveyed to the liquid salt. In this type of externally heated furnace, a large temperature gradient must be maintained between the combustion chamber and the salt bath in order to force the heat through the pot wall. For example, to maintain an adequate heat flow to a bath operating at 1500 degrees F., the combustion chamber temperature is usually kept above 2000 degrees F. The thermal efficiency of this type furnace must obviously be very low. Under actual production conditions it rarely exceeds 6 per cent.

While there are many disadvantages in operating such fuel-fired furnaces, the most serious one is the exorbitant pot maintenance cost. The life of a cast steel pot, used with a bath operating from 1500 to 1600 degrees F., may vary from a few hours to 1500 hr., due chiefly to the corrosive effect of the flames on the outside of the pot. This factor, coupled with the poor operating efficiency and atrocious working conditions caused by the excessive radiated heat, has limited the use of fuel-fired pot furnaces for temperatures above 1200 degrees F. to rather small units. Nevertheless, there are many thousands of these small salt baths in service today, and the fact that they are tolerated at all speaks volumes for the metallurgical results that can be obtained from them compared with other heating media.

Attempts have been made to utilize the conventional electric heating element in these pot type furnaces. Nickel-chromium heating elements mounted on the walls of the furnace radiate their heat to the outside surface of the pot. As is well known, such metallic heating elements cannot be operated continuously above 1900 degrees F., which does not afford sufficient temperature head to operate a bath above 1500 degrees F. When a cold charge is immersed in the bath, it chills the salt very appreciably and with a limited temperature available in the heating chamber, the bath recovers its temperature much too slowly after the work is immersed. Furthermore, certain salt fumes, such as sodium cyanide, result in rapid deterioration of the heating elements and they are quite costly to replace. For these reasons, and other limitations, this type of externally heated electric salt bath furnace has never gained commercial prominence.

As far back as 1906, attempts were made to overcome the shortcomings of externally fired salt baths by generating heat electrically within the bath itself. All salts, while good insulators in the solid state, become fairly good conductors when melted. This electrical characteristic was used by a European furnace designer and resulted in the first immersed electrode type furnace about 35 years ago. The electrodes were arranged on opposite sides of a refractory pot and a low voltage applied to their exposed ends. Current then traversed the liquid bath between these electrodes, and heat was generated by virtue of the resistance of molten salt to the flow of current. A fairly uniform temperature resulted throughout the contents of the pot, even when operated as high as 2350 degrees F. for hardening high speed steel tools. Unfortunately, this condition became

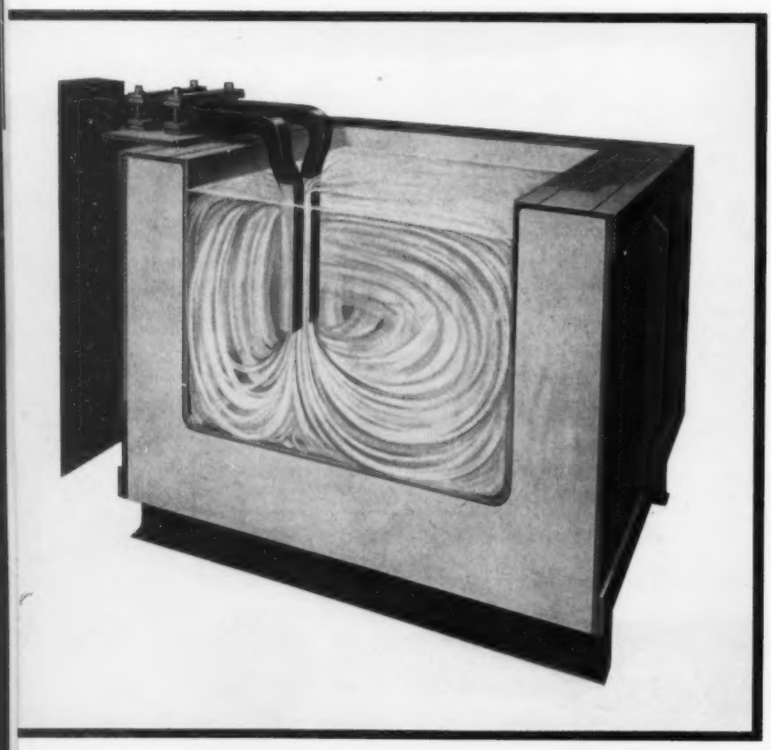


Figure 1—Electromagnetic forces at the electrodes produce a vigorous circulation throughout the bath in the downward direction indicated.

By William Adams, Jr.,

Vice-President

AJAX ELECTRIC COMPANY, INC.,

PHILADELPHIA, PENNA.

Presented before the A.I.S.E. Cleveland District Section, at Cleveland, Ohio, January 6, 1941, and Youngstown, Ohio, January 7, 1941.

seriously disturbed when the work to be treated was immersed in the bath. Steel, of course, is always a much better conductor of electricity than molten salt and in a furnace of this type, where the current passed through the region of the bath in which the work was immersed, local overheating resulted due to the current crowding into the steel. In fact, the current concentration became so great in work having unequal sections, such as a threading chaser, that portions of it melted although the temperature of the bath itself was unaltered. This furnace has found a limited use in Europe, but several attempts to introduce it in this country have met with no success. In addition to the danger of overheating the work, serious problems are presented in maintaining refractory pots plus the difficulty of melting the solidified bath. The widely spaced electrodes present difficulties in creating a pool of conducting liquid salt between them.

It remained for Hultgren, a prominent Swedish metallurgist, to point the way of avoiding the danger of local overheating in the work, and, at the same time, retain the simplicity and inherent metallurgical advantages of the immersed electrode type salt bath furnace. It is the object of this paper to describe this furnace development, and to give some data pertaining to the heat treating operations to which it has been applied. That it has found widespread application since its introduction in 1936 is indicated by the fact that nearly 350 installations have been made with a total connected load of approximately 25,000 kw.

While most of you are familiar with the operating principle of this furnace, it may not be amiss to review it briefly again. Any ordinary shop voltage, such as 220, 440 or 550 volts, is impressed on the primary of a step-down transformer, the secondary of which provides a low voltage directly connected to the terminals of the electrodes. A group of electrodes, usually a pair, are immersed in the salt, which, being melted, is an electrical conductor. These electrodes are closely spaced, leaving only a gap of one to two inches between them.

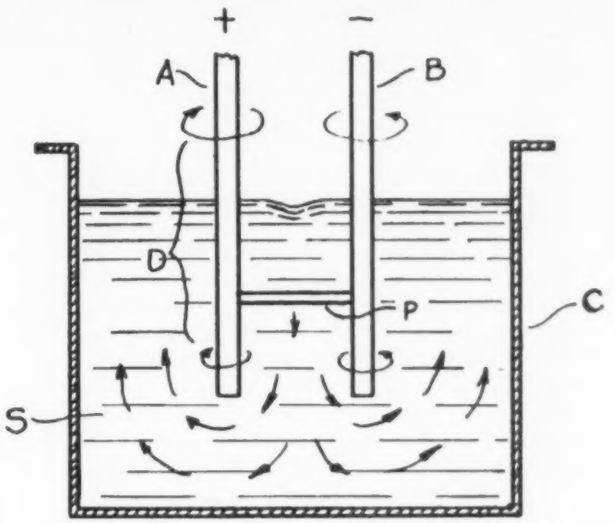


Figure 2—Diagrammatic view of electrode system explaining theory that produces electromagnetic field.

A low voltage, from 5 to 25 volts, is impressed across the electrodes. Alternating current then flows through the liquid salt lying in the gap between the electrodes, which heats the salt by virtue of its own resistance to this flow of current. The groups of electrodes are arranged in close proximity along one side of the bath, so that the heating zone is kept separate and distinct from the working space. The close electrode spacing makes it possible to utilize the electromagnetic forces at the electrodes to produce a vigorous circulation throughout the bath. This electromagnetic circulation causes the liquid salt to be drawn into the gap between the electrodes and sucked downwardly. To maintain

Figure 3—Battery of furnaces used by large automotive plant for case hardening clutch plates used in automatic transmissions.

equilibrium in the bath there is an upward flow at the sides of the pot to replace the liquid forced down from the top. This circulation literally takes the heat away as fast as it is generated between the electrodes and assures uniform temperatures throughout the bath.

Figure 2 explains the theory of this electromagnetic circulation. Any conductor which carries current, when placed in a magnetic field, tends to move at right angles to the direction of the magnetic field and at right angles to the direction of flow of the current. Applying this rule to the salt bath, by way of explanation, electrodes *A* and *B* are immersed vertically and close together in a molten salt *S* held in the vessel *C*, and a current of high magnitude, 3000 amperes for example, is passed between them. Each electrode is surrounded by approximately circular lines of force *D*. Current of uniform density flows between the electrodes at all points from the surface of the liquid to their ends. If a current element *P* is taken midway between the two electrodes,

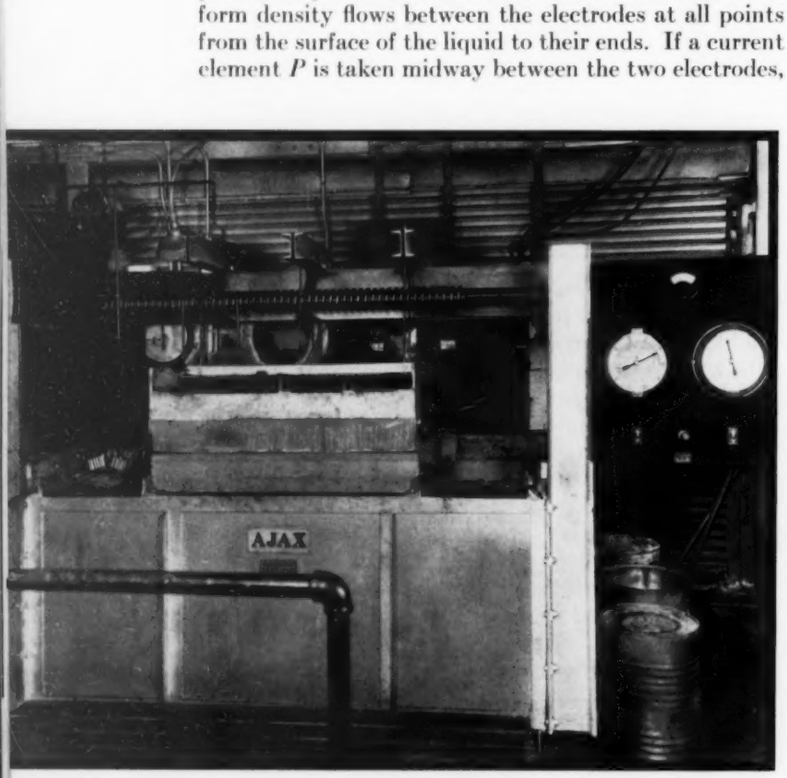


Figure 4—Carburizing gears in activated cyanide bath. Work charged at one end is supported and conveyed through bath by overhead screw.

and some distance down from the surface, and the current is traveling at any instant from *A* to *B*, then with the resultant electromagnetic field between the two electrodes extending outward from the plane of the figure at the point *P*, the conductor, or element of the liquid salt which is carrying the current, will be forced downward between the electrodes in the direction of the arrow. If the direction of the current is reversed, the direction of the magnetic field automatically reverses, and the direction of movement is still downward.

The force of the circulation is greatest where the electrodes emerge at the surface of the bath, and falls off gradually as the depth increases and as the end of the electrode system is approached. This follows from the fact that all the current is flowing in the electrodes at the upper end, but less and less flows in them at lower points. Hence the field of force *D*, as shown, is many times stronger at the top than at the bottom. In addition to the force just described, there are other minor electromagnetic forces, such as pinch effect, repulsion and crowding effects, which assist and contribute to the downward flow.

For baths requiring a large power input, polyphase currents are used. In this case, electrodes in groups of three are employed, but the electromagnetic circulation is essentially the same as in the case of the single phase arrangement using a pair of electrodes.

Automatic temperature control is provided by means of the usual train of apparatus, *i.e.*, thermocouple, pyrometer controller and magnetic contactor. The thermocouple, protected by a metal sheath, is immersed in the bath.

Now, let us examine some of the results obtained with this type salt bath furnace in commercial practice. I shall confine this to the more common heat treatments, such as cyanide hardening, carburizing, neutral hardening of carbon steels and high speed steel tools, age hardening and tempering, annealing, brazing, selective heating, and forging.

CYANIDE HARDENING

More salt bath furnaces, both fuel-fired and electric, are used for hardening finished carbon and alloy steel parts in sodium cyanide baths than for any other heat treating operation. As an illustration, over 75 per cent of all automotive transmission gears are cyanide hardened today. It is generally considered the ideal heating medium for hardening finished machined work, because it not only prevents any decarburization but produces a file-hard wearing surface or case. Straight sodium cyanide baths, containing from 5 to 30 per cent of sodium cyanide, and operated at temperatures from 1450 to 1650 degrees F., will produce a case depth up to .010 in. It was in this field of work that the furnace under discussion made its debut. A careful investigation of the performance of gas and oil fired cyanide furnaces showed that they rarely operated with a thermal efficiency of more than 6 per cent, and cast steel pots had a life of only one to six weeks. The internal heating principle of the electrode type furnace seemed ideally adapted to compete with this fuel-fired equipment on a direct operating cost basis, without resorting to the more intangible arguments for electric heat, such as better temperature control, improved working conditions, etc. Experience quickly justified the wisdom of selecting the field of cyanide hardening as an entering wedge for the electrode type furnace. Over 150 installations in this field have shown that power costs are no more than fuel in furnaces using natural gas, and considerable less compared with city gas. It is merely a matter of comparing thermal efficiencies of about 65 per cent in the electrode type furnace with 4 to 7 per cent in fuel-fired equipment.

What seemed to surprise the industry most, however,

was the simple solution of the pot problem. We use plain, welded steel boiler plate pots, and several installations have been in continuous operation for three years. The average life, however, is more nearly 18 months, or about twelve times the pot life that can be expected from gas fired pot furnaces under similar conditions.

CARBURIZING

As a result of the activated cyanide baths developed by leading salt manufacturers during the past seven years, it is now possible to produce case depths in the electrode type furnace up to ⅛ in. This may seem like an exaggerated claim, when it is considered that you will find nothing in the literature or even the propaganda of liquid carburizer catalogs contending that case depths greater than .050 in. are possible by the salt bath method. But something of a rather startling nature has happened in the past few months, the impetus of which came from our present military defense program. I am sorry that I am not at liberty to go into details, but you will be interested to know that a battery of these furnaces is now in commercial operation producing light armor plate, with a carburized surface up to ⅛ in. in thickness.

Commercial work rarely calls for carburizing steel parts to a greater depth than .040 in. It is often claimed that liquid carburizing is faster than other carburizing methods, such as pack or gas carburizing. I don't think this is strictly true. Much evidence points to the fact that any of the carburizing methods, when performed in a properly designed furnace, will produce a given case depth in about the same time. However, it is quite obvious that work immersed in a liquid bath will reach the carburizing temperature of 1600 to 1750 degrees F. much faster than in a furnace where the heating-up rate is dependent upon radiant heat.

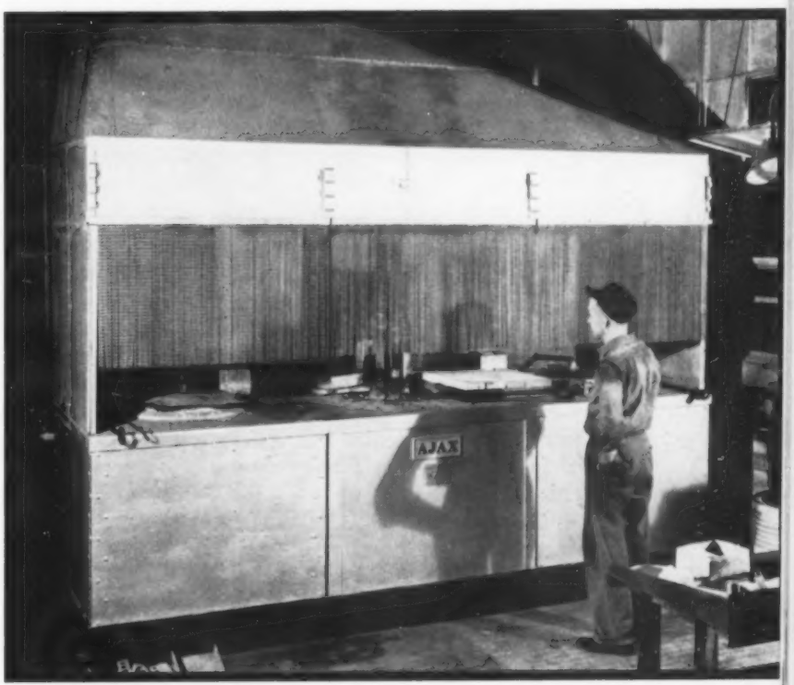


Figure 5—Preheat, high heat, and quench furnaces for hardening high speed steel tools at temperatures up to 2400 degrees F.

This time saving factor becomes more important the shorter the carburizing cycle. Thus if we consider the case where two hours are required to produce the desired case depth, and it takes only 10 min. to bring the work to temperature in the salt bath compared with one hour by another method, then there is a net gain of 50 min. per charge in favor of the liquid carburizing method.

There is a noticeable difference in the character of the case produced by an activated cyanide bath compared with other carburizing methods. The active element in the bath is sodium cyanide (NaCN) which is first oxidized by its contact with air to produce sodium cyanate (NaCNO). When this cyanate decomposes, carbon monoxide (CO) and nascent nitrogen (N) are evolved. The carbon monoxide transfers carbon to the steel surface, and the nascent nitrogen is absorbed to form the characteristic hard iron nitrides. This nitriding element, present in liquid carburizing, is not present in other carburizing processes.

NEUTRAL HARDENING

About the most exacting heat treating operation encountered in industry is the hardening of high speed steel tools. All we are asked to do is to heat the steel right up to the point of incipient fusion, 2200 to 2400 degrees F., and retain a bright clean surface without any surface imperfections or shrinkage. That this problem has definitely been solved is best indicated by the statement recently publicized by a leading commercial steel treating company, which says:

"While it is perhaps dangerous to characterize anything in these fast moving times as the ultimate answer to troublesome problems, our own experience with commercial salt bath hardening of high speed steel would indicate that the advantages of the process can hardly be exaggerated. Irrespective of the size, shape or analysis, we have yet to see a tool come through the salt bath treatment with rounded corners, scale, pits or the slightest trace of decarburization. We feel that results are, as a matter of conservative fact, as close to perfection as we are ever likely to find."

Neutral hardening of carbon and alloy steels at temperatures from 1500 to 1650 degrees F. would appear to offer less obstacles than hardening high speed steels at much higher temperatures. Actually the problem has been more stubborn, and only recently have neutral salt baths become available that seem to give some hope of handling work satisfactorily at these medium temperatures.

AGE HARDENING AND TEMPERING

I prefer to discuss these two widely different types of heat treatments jointly, because they come within

the low range of temperatures and are done in the same kind of salt baths, namely, nitrate or nitrate mixtures. The most outstanding example of age hardening is presented by the aluminum alloys as used in the aircraft industry. Extremely close temperature control is required and rapid heating has special significance. Some of these aluminum alloys are subject to grain growth through a temperature range from 700 to 800 degrees F., whereas the grains are unaffected at the critical hardening temperature of 940 degrees F. This is quite different from the factors governing grain growth in iron alloys, where it is purely a function of time and temperature.

I doubt if there is a single aircraft plant in the country that doesn't have at least one salt bath for treating aluminum alloys. For one reason, the Navy Department is quite specific in indicating the type furnace to be used. In this field, we have installed electrode type furnaces with bath dimensions as great as 18 ft. long by 3 ft. wide by 5 ft. deep, and a connected load of 250 kw.

For drawing steel parts in the temperature range of 300 to 1100 degrees F., the salt bath is just another good way of doing it. Admittedly, the forced convection type furnace is doing a very fine job.

ANNEALING

The salt bath method has only a limited application for annealing. Where the metallurgical requirements dictate holding the work at a given temperature and then slowly cooling it in the furnace, the salt bath cannot be used if the final furnace temperature is below the freezing point of the salt. In most cases, this will be found to be so because the choice of salt mixtures for annealing purposes is very limited. For example, the chloride-carbonate salt used for annealing at 1200 to 1500 degrees F. has a melting point slightly above 1000 degrees F. Therefore, if it is desired to slowly cool the charge from say 1375 to 900 degrees F.—as is often required in spheroidizing—it obviously cannot be accomplished in a salt bath.

The salt bath has, however, done a splendid job in annealing work where it is simply a matter of heating to a given temperature as quickly as possible, holding the work at temperature for a short soaking period and then quenching in water or cooling in air or an insulated chamber. Some such typical operations are annealing low and high carbon steel wire in coils, sterling silver wire, bars and stampings, copper alloy bars and rods, etc.

BRAZING

The development of salt baths for specific purposes is largely a matter of trial and error. The chemistry of molten salt mixtures gives very little prior information as to what actual results can be obtained. In a way, this may be fortunate when we compare progress with the controlled atmosphere furnaces. Gas atmospheres consist of chemical compounds well known in elementary chemistry, and it is quite easy to erect a plausible hypothesis about how they react with each other and the hot metal, but not so easy, one may venture to remark, to make them act that way in an operating furnace.

Out of such cut and try research work, we were able to develop an entirely new brazing technique, namely, dip brazing in a molten salt bath. By the very simple process of dipping either ferrous or non-ferrous assemblies in the electrode type salt bath furnace, any number of joints may be brazed simultaneously in a matter of seconds. As soon as the immersed joint has reached the bath temperature, which is maintained slightly above the melting point of the brazing alloy, it is removed, quickly quenched or slowly cooled in air as required. The protective film of salt prevents scaling or decarburization.

In many respects, this new method reverses the brazing technique as employed in hydrogen brazing furnaces. Instead of enveloping the work in a gaseous atmosphere, slowly heating the assembly and finally cooling it down even more slowly in closed chambers, the salt bath dip brazing process seals the work from all atmosphere or fluxes and consequently simplifies the entire operation.

The decarburizing difficulties encountered in brazing carbon steel parts in hydrogen furnaces—necessitating a costly reheating operation to correct the damage done in brazing—is not only avoided but the work can be simultaneously carburized and brazed if desired. One salt bath brazing installation is producing 600 sets of Bendix type starters per hour. The starter consists of three separate assemblies, which are brazed and carburized to a depth of .018 in., all in one heating operation. Muntz metal is used for the brazing alloy and the bath is operated at a temperature of 1675 degrees F. The single furnace used for this production has bath dimensions of only 42 in. long by 20 in. wide by 18 in. deep. The cost of the equipment is about one-fourth of a hydrogen brazing furnace of equal capacity.

Other commercial salt bath installations are being used for brazing such work as copper heat exchange units, business machine stampings, steel oil filters used in automobiles, etc.

SELECTIVE HEATING

Except for work that lends itself to induction heating or lead baths, the salt bath offers probably the only solution for selective or end heating operations. The dip brazing process just mentioned is a good example of selective heating. Some others are selectively carburizing steel parts of various kinds, such as pinion gears for tractors. Perhaps the most spectacular use to which the salt bath has been put is in connection with the nosing or closing-in operation in the manufacture of artillery shells and bombs. This operation requires heating only a portion of the length of a hollow, tubular forging to a temperature which permits the end to be closed-in in a press to form the nose of the shell. The temperatures used vary from 1850 to 2100 degrees F., depending on the size shell and wall thickness. This is a very fussy job and the requirements for first class work can be summarized as follows:

(1) Uniform temperature of heated section regardless of variation in wall thickness.

(2) Exact control of the length heated.

(3) Sharp break between heated and cold section. This is necessary in order to retain adequate strength in the cold portion of the shell and hold its shape while the nose is being formed.

(4) Heated section must be parallel to the base of the shell, otherwise wrinkles or eccentricity result.

(5) Scaling and decarburization should be entirely avoided. This is particularly important with respect to the inside of the shell because it is very difficult to sand blast it after nosing.

The slot-type and rotary fuel-fired furnaces which have been used for this heating operation fall far short of meeting the above requirements, whereas the salt bath meets all of these ideal requirements perfectly. We have already installed, or are in process of installing, 15 salt baths for this shell nosing operation. These furnaces will handle 75 mm., 90 mm., 105 mm., 155 mm., 5 in. A.A. shells, and the largest installation will nose bombs with outside diameters of 14 and 18 in. This bomb job consists of three 700 kw. furnaces, each with a bath measuring 13 ft. long by 3 ft. wide by 3 ft. deep. Certainly this is a rather bold advance in salt bath furnace design compared with the conventional gas fired pot furnace of only a few years ago.

FORGING

The shell heating application just discussed is, of course, a forging operation. A few other rather interesting forging jobs are now being done, such as heating carbon steel bars for upset forging work. Our venture into this field is quite recent and it is too premature to make wild claims that cannot be substantiated with factual data. When we look back over the past twenty years and see the wreckage of other attempts made to apply electric heat to the forging industry, we must proceed with caution. In any event it does appear that the inherent advantages of the electrode type salt bath furnace offers a new approach to meet the severe requrements of the forging field.

Dunkak Discussion

(*Continued from Page 77*)

ment in some cases, on furnaces where the fuel and air are premixed, and we have devised what you could call a "soft head" which is simply a means of relieving the pressure by using a low pressure-diagram. I was curious to know if this is what Mr. Dunkak called a soft head and if so, what the material was that he used.

E. B. DUNKAK: By soft heads we mean friable discs that rupture at predetermined above-normal pressures. These we term a non-automatic portion of our safety equipment; and, at the present time, for steel mill service, we use cast iron and cast steel fixtures with friable discs of sheet zinc, the thickness of the disc depending upon its diameter and line pressure.

W. N. HORKO: Have you ever experienced any corrosion in the immersion heater itself?

E. B. DUNKAK: At temperatures below 1250 degrees F. no lead line corrosion is noticeable; that is, to a degree where economics are affected.

For temperatures higher than this, there is an accentuation of corrosion, probably caused by a combination of lead in the vapor phase, room atmosphere, together with the action of various oxides of lead that are present.

For wire pan work, low carbon steel has thus far proved to be most economical.

Stoltz Discussion

(*Coutinned from Page 80*)

whether or not a detrimental quantity of dirt will be collected on the motor windings.

Some applications require ventilation. Motors such as used on reversing blooming mills or on tandem cold rolled strip mills are required to operate at slow speeds with full load or greater current which continues to produce heat at the same rate in spite of the fact the motor is turning over slowly. While the motor may be capable of developing sufficient windage from its own blower to circulate sufficient air through it to keep it cool at the top speed, it is not able to develop sufficient pressure at slow speeds to provide the necessary air circulation at the slow speed. For this reason artificial ventilation must be installed. Where this is done we more often include air filtering equipment than on installations where the apparatus is rotating at its normal speed continuously and does not require artificial ventilation.

Protection against bad atmospheric conditions is more frequently installed with large motors and generators than on small. This is due to the greater cost of repair and also on the possibility that a shutdown involves more loss than would be obtained from a small machine.

In recent years fan cooled motors have been developed which are not only enclosed to protect the windings from the dirt, but are provided with a system of ventilation to keep it cool. Since the cooling air is always kept inside the motor there is no need of filtering equipment.

G. F. BEGOON: There are a couple of installations that are interesting for rotating electrical equipment in the motor rooms in steel mills. The same thing applies in power plants to the same degree because you possibly have the same amount of dirt, and one of the first installations of this division is being made by Commonwealth and Southern, at the Ohio Edison at their Akron plant. It is 40,000 cu. ft. per min. They are cleaning the air for 20,000 kva. synchronous condenser. The Rochester Electric Company has a real problem. They have some dust sources next to them, but they are putting in a 1000 cu. ft. per min. unit to clean that amount of air. They are cleaning in the generator room and by cleaning that amount of air, they feel they will get pretty good cleaning compared with what they have.

For cleaning the ventilating air for all types of large electrical rotating machinery, it seems that, as Mr. Stoltz has said, there is a very definite trend to a better method of cleaning the air than has been used in the past.

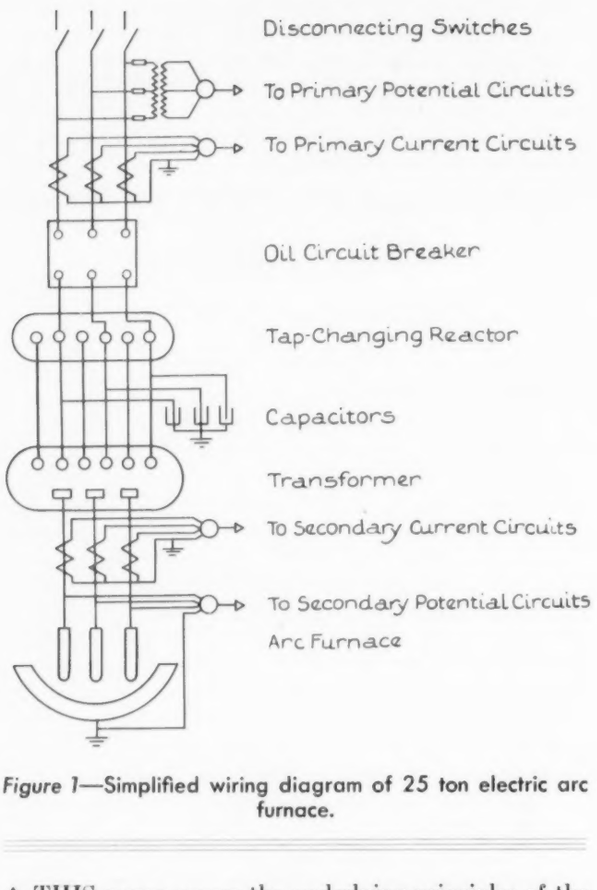


Figure 1—Simplified wiring diagram of 25 ton electric arc furnace.

An Investigation

The publication of this paper had been postponed to await the confirmation that the analysis of the phenomena found in the Bethlehem circuit and presented here was more universal of furnace circuits than the study of this one isolated case could indicate.

Mr. Black, who is superintendent of the electrical department, Bethlehem Steel Company, Bethlehem, Pennsylvania, and Mr. Boehne of the switchgear engineering division, General Electric Company, Philadelphia, Pennsylvania, presented the paper before the A.I.S.E. Philadelphia District Section, December 2, 1940.

▲ THIS paper covers the underlying principles of the electric arc furnace and deals with special investigation of over-voltages associated with the switching of the power supply to a 25 ton electric arc furnace at the Bethlehem plant of the Bethlehem Steel Company. Surge voltages, records and magnetic oscillograms, with and without surge protection features, are presented as part of the study on this installation.

The attention of the steel industry today is focused on alloy steels. Electric steel has denoted for some time superior steels made in the electric arc furnace and the increasing usefulness of the electric arc steel melting furnace as a tool in steel melting service (for ends which cannot be attained quite so well by any other method of heat utilization) is predicated upon the fact that specifications for alloy steels are becoming more and more rigid.

In the making of a heat of steel there are some fundamentals which it would be well to mention briefly in order that the references thereto in connection with the electric arc furnace which are to follow may be understood. As in other melting processes, arc electric furnace steel is made by both the acid and basic processes.

In the acid process, the hearth and side walls up to a point above the slag line, consist of acid refractories. During the melting of an acid heat, the acid slag acts as a shield to prevent oxidation of the molten metal and serves as a temperature equalizer. While there is some refining reaction from the slag during the later stages of the refining operation, the reactions between metal and slag in the acid process are far less important than is the case in the acid open hearth furnace or in the basic electric process.

The basic process is a combination of melting and refining, and the slag, in addition to acting as a protective agent during melting, later serves as a refining agent. The basic arc electric process can be divided into three prime operations:

A. Melting and oxidation
B. Refining and deoxidation
C. Finishing

In the production of high grade steel in the basic electric furnace it is general practice to remove the slag formed during the oxidation period, thereby eliminating phosphorus and other impurities which it is desired to keep out of the finished product. For carrying out the refining and deoxidation period, a new slag is formed on the bath, in which a rather close chemical balance is maintained. In the treatment of this slag with reducing agents, the removal of impurities such as sulphur, and a high state of deoxidation is accomplished, with the formation at the height of this period of calcium carbide and other compounds in the slag having very high deoxidation power. The finishing period is a continuation of the previous period and has as its object the attainment of proper temperature, correction of composition by addition of alloys, etc., and preparation for tapping. For an electric arc furnace, a brief review of fundamental characteristics peculiar to this type of electric circuit will serve to simplify the furnace discussion later on.

Alternating current arcs, between carbon or graphite electrodes and the common metal electrode or charge, are used practically exclusively in modern arc furnaces. With alternating current, the arc is extinguished at the end of each half cycle. A certain instantaneous value of voltage must be reached before the flow of current will start.

If the gap between the electrodes contains metal vapor—as is the case in metal melting furnaces—the current may start practically simultaneously with the voltage. Much has been written on the subject of arc power-factor and, of course, theoretically the ratio of

# of Over Voltages Associated with ARC FURNACE OPERATION

By L. V. Black and E. W. Boehne

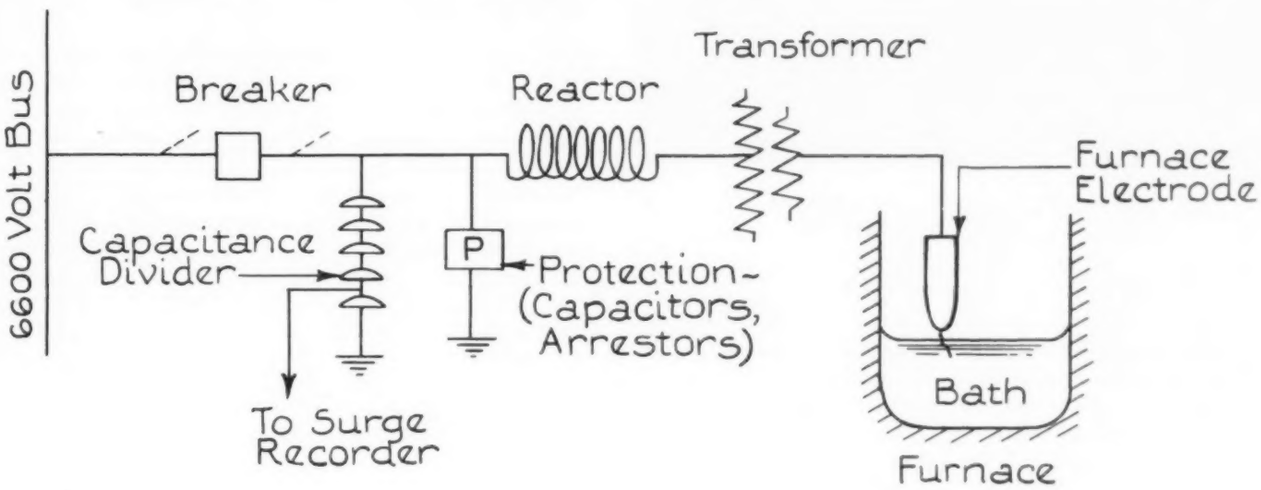
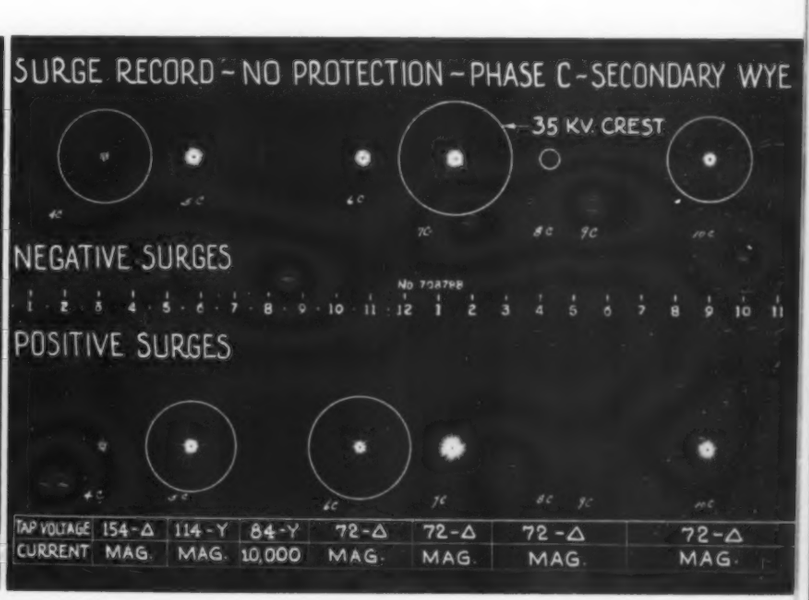


Figure 2—Single line diagram showing arrangement of equipment on three phase arc furnace installation.

Figure 3—Representative record of surges on one phase of electric arc furnace circuit.

Figure 4—Record of surges, simultaneous to those of Figure 3, on adjacent phase.


SURGE RECORD - NO PROTECTION - PHASE C - SECONDARY WYE
35 KV. CREST
NEGATIVE SURGES
POSITIVE SURGES
TAP VOLTAGE 154-Δ 114-Y 84-Y 72-Δ 72-Δ 72-Δ 72-Δ
CURRENT MAG. MAG. 10,000 MAG. MAG. MAG. MAG.

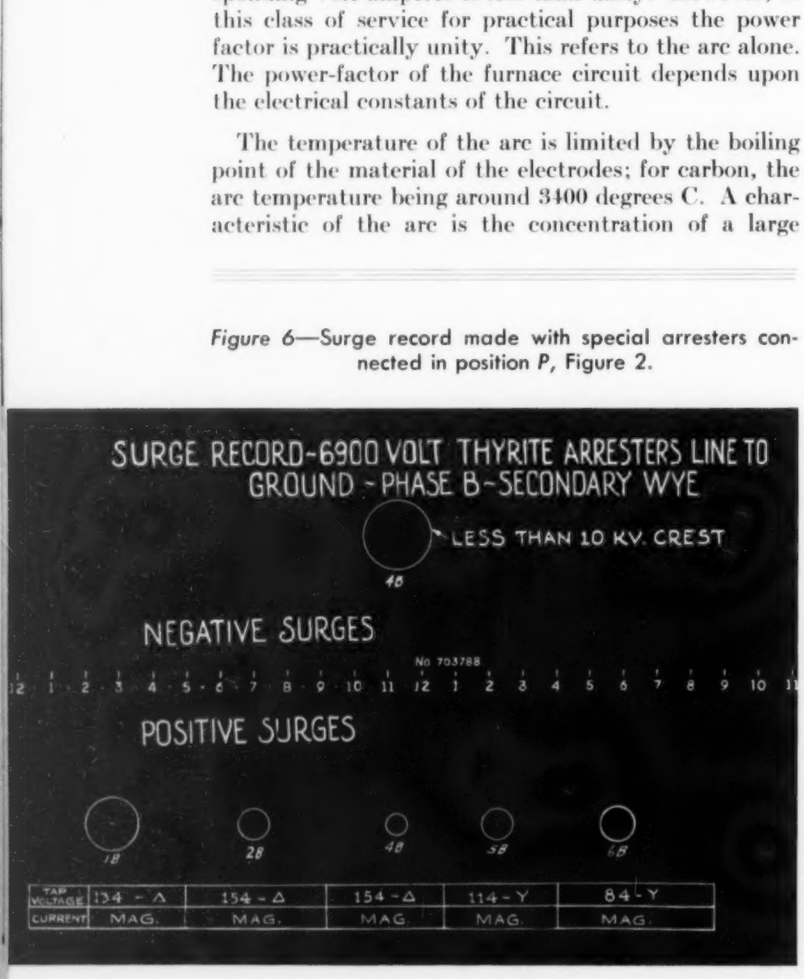
3182 LINE VOLTS - 540 VOLTS PER MILLIMETER
CP
8203 LINE VOLTS - - - 762 VOLTS PER MILLIMETER
TRAVEL RECORD OF CROSSHEAD - 1/6 INCH INDICATIONS
X1 LINE AMPS A 9 - - - 60 AMPS PER MILLIMETER
X2 LINE AMPS A 10 - - - 60 AMPS PER MILLIMETER
X3 LINE AMPS A 11 - - - 62.5 AMPS PER MILLIMETER
1086
Amps
Interrupted

Figure 5—Record showing arcing periods, with a maximum of .95 cycle period for interrupting 1086 amperes.

the watts in an alternating current arc and the corresponding volt amperes is less than unity. However, in this class of service for practical purposes the power factor is practically unity. This refers to the arc alone. The power-factor of the furnace circuit depends upon the electrical constants of the circuit.

The temperature of the arc is limited by the boiling point of the material of the electrodes; for carbon, the arc temperature being around 3400 degrees C. A characteristic of the arc is the concentration of a large

Figure 6—Surge record made with special arresters connected in position *P*, Figure 2.


SURGE RECORD-6900 VOLT THYRITE ARRESTERS LINE TO GROUND - PHASE B-SECONDARY WYE
LESS THAN 10 KV. CREST
NEGATIVE SURGES
No 703788
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11
POSITIVE SURGES
1B
2B
4B
5B
6B
TAP VOLTAGE 134 - Δ 154 - Δ 154 - Δ 114 - Y 84 - Y
CURRENT MAG. MAG. MAG. MAG. MAG.

amount of power within a small volume of the furnace charge, giving a high temperature gradient to the charge, with consequent high melting rate, an essential feature for this class of service.

The inherent volt ampere characteristic of an electric arc is such that energy in the arc is supplied in an unstable form. The condition for stability in an electric circuit is met only when the volt ampere characteristic of the circuit shows an increase of voltage simultaneous with an increase of current. The stabilizing element for a 3-phase arc furnace is usually provided in the form of a reactor. The only objection to reactance is the adverse effect its use produces on the power factor of the circuit. There is always, too, some resistance, that of the conductors in series with the arc, usually, however, a negligible quantity, but it tends to produce a stabilizing influence.

There are other factors which affect the stability of an arc in a metal melting furnace, such as excessive gas pressures, free oxygen, etc., but none of these are particularly troublesome in the ordinary operation of the electric arc furnace.

The size of three-phase arc furnaces used in the iron and steel industry ranges from 500 kva. to 7500 kva., as measured by the rating of the electrical equipment.

The general construction features of an arc furnace as manufactured in this country vary, of course, with size and with the different manufacturers. The shell of a typical furnace consists of a steel plate construction with a refractory lining and is usually circular in cross-section. The hearth is a shallow bowl formed in the refractory lining of the bottom. The lining may be of acid or basic refractories. Suitable doors for charging the metal to be melted and a pouring spout for discharging the finished metal are provided. The roof is a removable member, made as a separate part for convenience in relining and also in some cases to provide for overhead mechanical charging. It is standard practice to carry a spare roof, so that relining of this part of the furnace can be done without interrupting the operation of the furnace. In the roof are three equidistant openings through which the vertical carbon electrodes can travel. In some designs the electrode manipulating mechanism is mounted on the side of the furnace shell, while on others it is mounted on a separate base. The electrodes proper are manipulated by winches operated by motors with reversing control. The tilting mechanisms of large furnaces are motor driven, and the motors are usually operated by manual reversing controllers.

One of the most common methods of stating the size of a three-phase arc furnace is to rate the furnace in terms of the holding capacity in tons of molten metal. The normal holding capacity usually refers to the weight of molten metal in the furnace with the surface of the molten metal in the furnace several inches below the level of the door sill.

The method of operating an arc furnace so far as the charging of cold scrap is concerned varies with the kind and degree of subdivision of the scrap. For instance, the weight of cold scrap in the form of roll turnings that can be charged in a furnace initially will rarely be enough to form the weight of molten metal desired, so that additional quantities can be added as the metal in the furnace becomes molten. This practice affects ad-

versely both the energy consumption of kwh. per ton and consumption of electrodes. The question of the proper method of charging cold scrap is one that should receive a great deal of attention in the operation of a three-phase arc furnace. Frequently, the poor performance of an arc furnace during the melting-down period can be directly attributed to the poor manner in which the cold scrap has been placed in the furnace, and any attention that the operating or producing departments may give to this phase of the operation will result in a better overall economy in the operation of the furnace.

So far as electrodes are concerned, the choice between carbon electrodes and graphite electrodes is mainly an economic consideration. The carbon electrode begins to oxidize at a lower temperature than the graphite electrode and consequently results in a greater electrode consumption.

To date designers have limited the open-circuit values of voltage of three-phase arc furnaces to 275 volts maximum. Above this value of voltage the problem of providing adequate electrical insulation of the main furnace secondary circuit becomes increasingly more difficult, but not impossible of attainment. The use of any voltage much higher than 275 volts would seriously impair the factor of safety of the furnace operating personnel.

The electric equipment of a three-phase arc furnace for steel melting service consists of the following:

(a) A transformer to step down the voltage of the power supply system to the voltage needed for the furnace.

(b) The secondary bus structure between the transformer and the furnace.

(c) Primary reactor (25 cycle furnace).

(d) Necessary switchgear to control power supply.

(e) Instrument and meter equipment.

(f) Electrode motors.

(g) An automatic current regulator.

(h) A motor for the tilting mechanism.

For arc furnace applications, transformers of special design are required. The secondary coil construction involves large heavy coils, requiring special bracing of the winding to meet the mechanical strength required with large variations of secondary current. Because of the magnitude of current required, multiple secondary coil construction is necessary, the individual secondary coil terminals are brought out through the transformer tank cover. The secondary windings can be connected either Y or delta. The installation of current transformers in secondary circuits handling currents in excess of 15,000 amperes is often a difficult problem. This problem is often simplified by inserting a current transformer in one of the multiple secondary coils for each phase, and calibrated to read the correct total secondary output of each phase.

Since a certain degree of flexibility of secondary voltages is desirable, the general method of changing secondary voltages delivered to the furnace, is by use of suitable taps in the primary winding. The number of these primary taps is dependent upon each individual furnace application. Suffice it to say that for ordinary steel melting service three distinct voltage steps are usually sufficient, each step being provided with one additional voltage tap of from 10 to 15 volts difference,

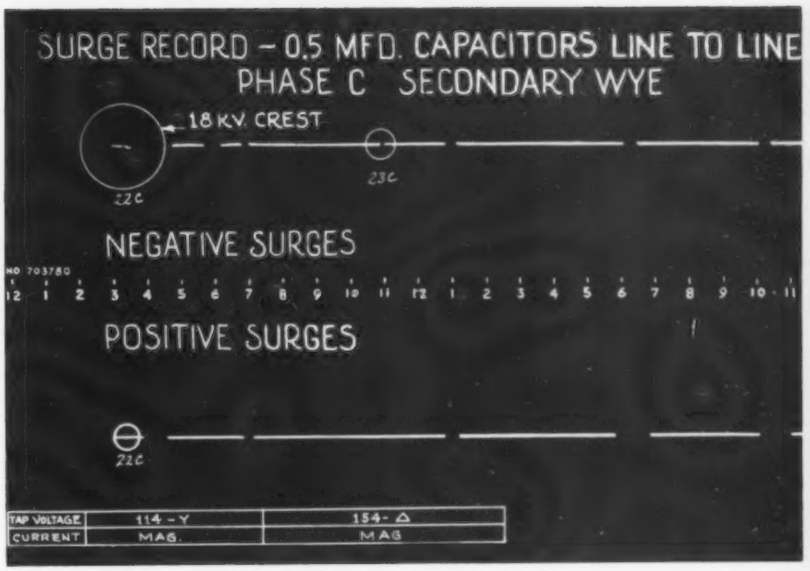

SURGE RECORD – 0.5 MFD. CAPACITORS LINE TO LINE
PHASE C SECONDARY WYE
18 KV. CREST
22C
23C
NEGATIVE SURGES
NO 703780
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11
POSITIVE SURGES
22C
TAP VOLTAGE 114 - Y 154 - Δ
CURRENT MAG. MAG

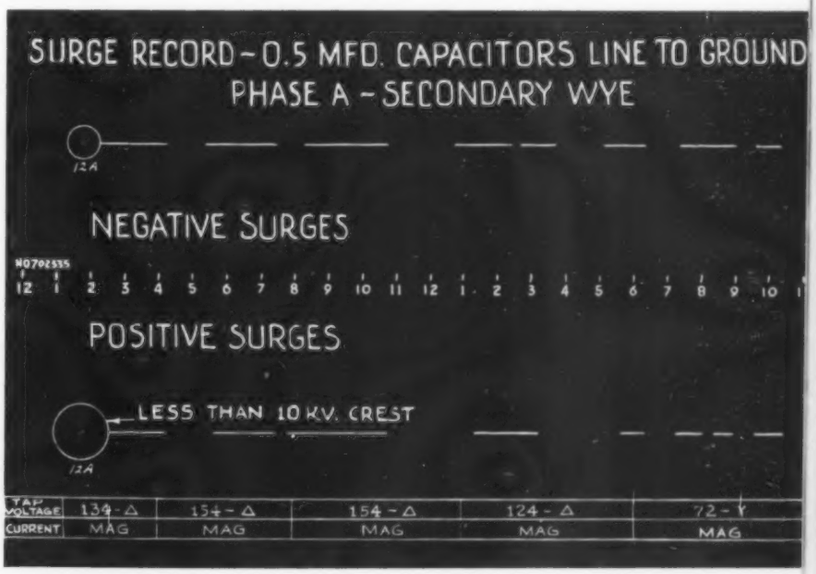
Figure 7—Surge record with .5 micro-farad capacitors connected phase to phase.

making a total of six voltages available with the primary winding connected delta. Resorting to the Y connection of primary winding would add another six, making a total of 12 voltage taps.

Since the electrode holders of practically all furnaces are water cooled, this feature makes the use of a water cooled transformer attractive, as a series water connection will supply both.

Comparing a three-phase arc transformer with three single phase transformers, space and first cost considerations generally favor the three-phase unit for arc furnace service.

Figure 8—Surge record with .5 micro-farad capacitors connected phase to ground.


SURGE RECORD – 0.5 MFD. CAPACITORS LINE TO GROUND
PHASE A – SECONDARY WYE
12A
NEGATIVE SURGES
NO702535
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10
POSITIVE SURGES
LESS THAN 10 KV. CREST
12A
TAP VOLTAGE 134 - Δ 134 - Δ 154 - Δ 124 - Δ 72 - Y
CURRENT MAG MAG MAG MAG MAG

In order to limit the short circuit currents during the intervals when the scrap begins to fall around the electrodes during the latter part of the melting-down cycle and more particularly to add stability to the operation of an arc furnace especially when operating on a 26 cycle power supply system, an external reactor is required. The total amount of reactance required will be dependent upon the amount of inherent reactance in the design of the transformer and secondary circuit, plus primary power supply system reactance. The reactor is usually provided with a no-load motor operated tap changing device. The manner of interlocking this device together with the no-load motor operated transformer tap changer is such as to insure that both tap changers are made inoperative with the oil circuit breaker closed. In the event that the oil circuit breaker is already open and any one or both of the motor operated tap changers are in operation, again the oil circuit breaker is electrically interlocked in such a manner as to prevent closing during the period of operation of tap changers.

So far as meters and instruments are concerned, a primary panel is required, containing all of the essential protective units, graphic wattmeters, integrating kwh. meter, together with indicating meters of primary voltage, current and power factor.

The operator's panel is usually mounted in a convenient place with reference to the operation of the furnace. The equipment essential to the control of energy to the furnace consists of the following:

(a) Three indicating lamps for visual indication of arc voltages.

(b) An ammeter in each arc circuit.

(c) Indicating wattmeter.

(d) A voltmeter across each arc.

(e) Three current adjusting rheostats.

(f) Automatic current regulator panel.

(g) No load tap changer control for main power transformer and reactor.

(h) Four control switches for changing from automatic to manual control or vice versa.

(i) Pyrometer for indicating temperature of main power transformer.

(j) Signal system indicating overheating of transformer or reactor, failure of d-c. or a-c. power to auxiliaries, failure of motor driven oil circulating pumps, failure of motor driven water filter units, etc.

In the operation of a furnace melting cold scrap, the function of the automatic current regulator is a very important feature, and the successful operation of an arc furnace very largely depends upon the precision of the regulator. Due to the rapid changes in the mechanical condition of the cold scrap during the melt-down period, the arc will be broken and made frequently and in order to avoid severe short-circuits and tripping of main power oil circuit breaker, the regulator must draw the electrodes out of the constantly caving-in materials at a high rate of speed. Precision of regulation is therefore a no less qualification than speed.

The circuit supplying power to the furnace is a very simple one. Figure 1 shows power taken from the plant high tension system at 6600 volts, three-phase, 25 cycles, through a set of disconnects, on oil circuit breaker, and reactor to the power transformer. Current and potential transformers are included for metering and protective relaying. Through proper switching the reactor is used with a delta connection of the primary winding of the transformer for the melt-down period. For refining the reactor is shorted out, and the primary winding of the transformer is connected wye. The secondary winding of the transformer is permanently connected in wye. Each phase is connected to a furnace electrode by means of a group of flexible stranded copper cables.

After the furnace is charged the operator runs each electrode down to the charge by hand, thus closing the secondary circuit to the transformer and melting of the charge is begun. The operator continues to operate the electrodes by hand for a short period at the start of each melt-down period until he has a stabilized arc. At this time he makes proper adjustments for the desired current and voltage, and transfers the control from hand to automatic. With this procedure the possibility of electrode breakage is greatly minimized.

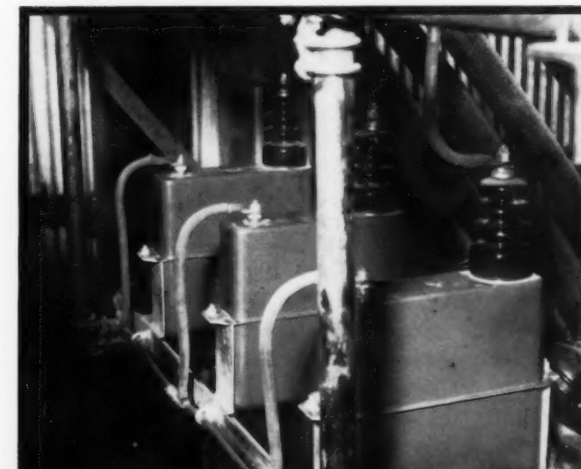


Figure 9—View showing installation of capacitors used to reduce surge magnitude on electric arc furnace.

To shut down the furnace for the removal of slag, additions to the charge, taking of test samples, etc., the electrodes are raised well above the charge, thus reducing the power consumption to a minimum, before the oil circuit breaker is opened.

Having described in a general way the nature of the operation of a three-phase arc furnace as applied to steel melting service, it should be restated that the quality of the product and the ability to reproduce analysis, time after time, are the technical and economic reasons for electric arc furnaces in the iron and steel industry.

In the foregoing paragraphs, the authors have en-

deavored to discuss the underlying principles governing the design and operation of the electric arc furnace as applied for steel melting service.

The application of control and switching equipment to the primary circuit of the electric arc furnace places quite versatile demands upon this equipment. For example, the circuit breaker must not only serve to protect the circuit in the event of secondary shorts or overloads but must also serve as a switching device under any and all conditions. It is not uncommon to find a furnace breaker operating 700 to 800 times a week. The interrupter application is not enhanced by the high reactance of the primary reactor and transformer combination. Probably the most striking difference between the furnace circuit and other industrial applications is the high ratio of voltage transformation. This fact coupled with the arc nature of the load with its erratic performance and non-uniform characteristics completes the story of one of our most unique industrial applications.

On one occasion a furnace oil circuit breaker was damaged during the furnace operation. It was, therefore, decided to investigate the possibility of voltage surges in a circuit of this character. Surge recorders were selected as a means of indicating and recording the presence of surges.

Figure 2 shows a single line diagram of the circuit showing the location of the surge recorders. It is significant to note that they are located only on the load side of the breaker, previous experience dictating that surges, if present, would occur only at this point. The surge recorders were coupled to the circuit by means of the capacitance provided by a string of insulators attached to the 6600 volt circuit. Surge recorders were attached at this point on all three phases. The film in the surge recorders are normally driven by a clock mechanism which permit a continuous record to be taken over a period of one week. Preliminary tests revealed, however, that surges only accompanied the switching operations and for this reason, part of the tests were conducted by turning the film by hand between successive tests.

Tests were first made over three complete heats with no protection equipment added, the three surge recorders being continuously operative at a speed which permitted the film to run out in about a 48 hr. period. Figure 3 shows a representative record of few of the surges on one phase; the highest surge on this phase being negative at 35 kv. Figure 4 shows the simultaneous surges on the adjacent phase. Here the maximum surge was positive at 70 kv. This surge represents the highest recorded value and was produced by tripping the primary breaker as the furnace electrodes were being raised, a situation requiring further specific investigation. Repeated tests produced many voltage surges, but the variables associated with their generation were not subject to control and duplicate performance at will was impossible.

Breaker Timing Tests. During the above study magnetic oscillograph records were taken of over 100 breaker operations; recording currents, arc duration, and breaker time for currents ranging from magnetizing value to load current values. Magnetizing currents were interrupted at the first current zero following contact parting. Overload currents required longer arcing periods, the longest recorded being 0.95 cycles on interrupting 1086 amperes, as shown in Figure 5.

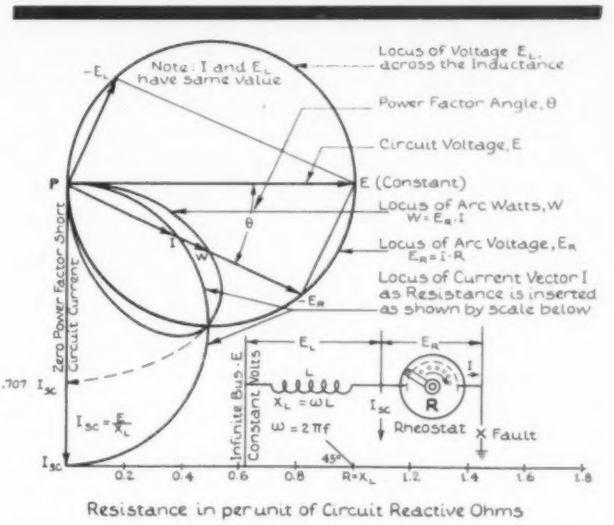


Figure 10—Circle diagram showing analysis of changes occurring as resistance is added to an otherwise reactive circuit.

Because of the magnitude of some of the surges recorded and because of the frequent occurrence of the surges in general, it was decided that some form of circuit protection was necessary. At first glance it may appear that a simple insulating gap located on the load side of the breaker might be the solution. Such a gap would permit the surges to discharge to ground harmlessly inasmuch as the power source would have been isolated from this portion of the circuit. Such a simple solution might be feasible on a single phase circuit; however, due to the 3 phase nature of the furnace circuit with the possibility of surges occurring on one phase before the breaker has cleared the other 2 phases, in addition to the possibility of gap-kindling surges entering the circuit from other sources, makes such a simple method impractical.

Arrester Tests. Tests were then made during two normal heats with special arresters connected in position *P* as shown in Figure 2. A study of these records revealed that the maximum surge was only 10 kv. as shown in Figure 6.

Capacitor Tests. Five-tenth micro-farad capacitors were then connected phase to phase and operated over two complete heats, with the result that the highest surge recorded during two heats was 18 kv., as shown in Figure 7. The capacitors were then connected phase to ground, like the arresters. Here the surges were reduced to less than 10 kv. as shown in Figure 8. When it is kept in mind that twice normal voltage crest to ground is over 10,000 volts, it will be appreciated that excellent protection has been obtained. Figure 9 shows the installation of the capacitors at the Bethlehem plant.

SUMMARY AND CONCLUSIONS

(1) Following a moderate amount of unexplained breakdowns of electrical equipment associated with the

operation of electric arc furnaces, this surge investigation was conducted which revealed that:

(a) No surges were produced as a result of interrupting overload currents.

(b) Surges were only produced as a result of interrupting the lighter currents.

(2) Lightning arresters and capacitors were both found suitable as a means of lowering the magnitude of the surges produced.

(3) Capacitors line to ground were found to be more effective than capacitors line to line.

(4) Capacitors line to ground were installed as a solution to this problem at the Bethlehem plant.

This paper would not be complete without some discussion of the fundamental nature of the surges at hand. At the outset it should be stated that no clean-cut positive description of the mechanism of the origin of the surges is available. On the other hand, a knowledge of the surge phenomena associated with kindred circuits involving the arc, such as rectifiers, vacuum switches, and the phenomena associated with the interruption of d-c. currents in inductive circuits, permit the broad fundamentals to be encompassed. From a practical viewpoint on the other hand, the important feature is that surges were found and a means was found for their suppression. It should be clearly understood that the following theoretical discussion represents only the personal views of the authors.

From a fundamental viewpoint, a voltage E is produced in an inductive circuit (L henrys) in proportion to the rate of change of current in the circuit. This proportionality is given by the well-known expression:

$$E = L\frac{di}{dt}$$

Now should the current drop suddenly to zero then di/dt would be infinite and the surge produced would be of infinite magnitude. Such would be the fact with any circuit containing pure inductance and no capacitance. Fortunately, however, capacitance is as unavoidable in an electric circuit as mass is with any physical object. All circuits contain some capacitance (C farads) although in some cases the value is quite small.

Now when a sudden drop in current, i_o, occurs in an inductive circuit (L) associated with a value of inherent circuit capacitance (C) the resulting crest voltage no longer follows the law given above but approaches the relationship:

$$E = i_o\sqrt{L/C}$$

Here the relation $\sqrt{L/C}$ is as purely an ohmic value as a blue stick resistor or a rheostat. Thus amperes (i_o) multiplied by ohms ($\sqrt{L/C}$) is volts as in all conventional circuits.

The furnace circuit is inherently of such a nature that L is high and, as an average, C is inherently low.

The remaining fundamental relationship, which forms another approach to and proof of these same considerations, concerns the energy trapped in the iron circuits of the reactor and the transformer. When a current i_o flows in an inductive circuit the kinetic energy stored is given by the relationship:

$$\text{Energy} = \tfrac{1}{2}Li_o^2 \text{ watt seconds.}$$

Hence when the current i_o is interrupted suddenly this stored kinetic energy can only appear as electrostatic energy (voltage) and heat. Assuming that all the energy goes into electrostatic energy, we have the equivalence:

$$\tfrac{1}{2}Li_o^2 = \tfrac{1}{2}CE^2 \text{ watt seconds}$$

From which $E^2 = i_o^2\dfrac{L}{C}$

or $$E = i_o\sqrt{L/C} \text{ volts}$$

This, it will be observed, is the same relationship that appears above.

It will be observed that the above expression for the voltage surge, although approximate and incomplete, does not contain any reference to the voltage of the circuit. It is generated by some small current i_o acting with the surge resistance ($\sqrt{L/C}$) of the circuit.

The application of capacitors to bhe inductive furnace circuit may create the feeling, in the uninitiated, that rertain resonant frequency hazards may lurk which require additional caution. These fears may be eliminated by both practical and theoretical considerations. For example, such shunt capacitors have been applied for over a period of 10 years to the terminals of transformers and rotating equipment for their surge protection, particularly where lightning is concerned. Capacitors are used freely across the winding of transformers associated with rectifier circuits. As far as the furnace and its arc are concerned it should be pointed out that the arc of the furnace, like any other arc, can only present a resistance to the circuit and, needless to say, such resistances are always positive. It is true that the arc in the furnace may change its resistance suddenly and in this way excite only the natural frequencies of the circuit and no others. The addition of capacitors at the high voltage terminal lowers the natural frequency of the high voltage winding and will lower the natural frequency of the secondary winding a slight amount. From the protection standpoint, the larger the capacitor the better. From a switching standpoint, other problems arise should the inductive reactance exceed the capacitive reactance and to avoid their consideration it is recommended to choose the value of capacitance such that the capacitive reactance does not drop below the inductive reactance. Since adequate protection is afforded by capacitors far less than these values, further discussion of this point is unnecessary.

Experience indicates that great care should be exercised in the selection of all apparatus used in the installation, and still greater study should be given to the proper protection of the various units. Adequate insulation is necessary to withstand possible high voltage surges, and circuit breakers of ample kva. interruption capacities are of prime importance. It is agreed that the application of capacitors on the 25-ton furnace at Bethlehem is a valuable addition to the installation.

DISCUSSION

PRESENTED BY

G. O. VAN ARTSDALEN, *Superintendent of Maintenance*, Henry Disston and Sons, Inc., Philadelphia, Pennsylvania

G. H. SCHAEFFER, *Electrical Engineer*, Carpenter Steel Company, Reading, Pennsylvania

J. C. REED, *Electrical Engineer*, Bethlehem Steel Company, Steelton, Pennsylvania

F. W. BROOKE, *Vice President*, Swindell-Dressler Corporation, Pittsburgh, Pennsylvania

R. H. LANG, *Superintendent*, Power Transmission Stations, Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Maryland

L. H. FISTER, *Assistant Superintendent*, Electrical Department, Bethlehem Steel Company, Bethlehem, Pennsylvania

CHARLES WASSERMAN, Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Maryland

H. B. PECK, Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Maryland

N. R. STANSEL, General Electric Company, Schenectady, New York

E. W. BOEHNE, Switchgear Engineering Division, General Electric Company, Philadelphia, Pennsylvania

G. O. VAN ARTSDALEN: I have only question one to ask: Is this really a very serious consideration, or is it only of serious concern on the larger furnaces? Of course we operate only the smaller sizes; very small, in comparison to the 25-ton furnaces, and as yet we have had no difficulty due to high instantaneous voltages. I would therefore like to ask what injury has been done to equipment to cause this amount of research to be made; whether any equipment has been damaged and whether the high-voltage surges are of such nature and short duration that they are harmless.

G. H. SCHAEFFER: How serious this problem is, I don't know. I think, to give any intelligent answer to it, you would have to know under what conditions these engineers have been conducting their tests. I think Mr. Van Artsdalen stated that he would like to know what damage has been done due to this high voltage. I have been trying to think of any damage we have suffered and do not recall that there has been any damage.

If we have a high voltage due to regular operation of the furnaces, what are we going to do to prevent it? Are we going to try to get slower operating control, or a faster-operating breaker? Are we going to speed up the breakers or slow up the controls?

I imagine from the theoretical point of view, there is a whole lot to think about. We have been speeding up and so far we have not suffered any damage. I feel, though, that Mr. Black has brought up something that deserves our earnest consideration.

J. C. REED: We have an electric furnace; it is only a 6-ton furnace, but I presume that relative capacity of our furnace is about the same to the Steelton plant power system as this 25-ton furnace is to the Bethlehem system—so we'll have to go over the situation and study it. I don't know whether we get high voltages or not, and maybe it is causing trouble in our apparatus that we don't know of. We use a reactor to hold down the short circuit current while melting the charge, but we haven't any capacitors. Whatever excess voltages we get seem to be absorbed by the system without causing any insulation breakdowns.

F. W. BROOKE: I think we have been a little unfair to Mr. Black by not appreciating enough his very first sentence of the paper. He pointed out that he was going to explain a phenomenon that occurred in his particular installation. I would like to take the liberty, if he will allow me, to compare that installation to what we look upon as a standard large installation.

While this Bethlehem installation is considered a large electric furnace it has an electrical rating of 7500 kva. whereas three-electrode furnaces, having electrical ratings as high as 12,000 kva., are being more and more used. In the case of one installation the electrical capacity is 20,000 kva., but this requires 6 electrodes, in other words two 3-phase banks, each 10,000 kva., incorporated into the one furnace.

The illustrations showing the arc phenomena are very interesting but I wonder whether this was really the cause of the break-down of the oil circuit breakers as has been generally inferred by the paper and by the discussion.

There have been other oil circuit breaker failures on different types of large furnaces but it is now generally acknowledged that these failures have been brought about by the fact that the modern electric furnace requires a very large number of makes and breaks per year.

The so-called standard oil circuit breaker has been designed to meet a service calling for something like a maximum of 1000 or perhaps 2000 makes and breaks per year. We recently installed a counting device on one of our large electric furnaces and found that the number of makes and breaks per year will probably add up to something like 20,000 to 30,000. This, of course, puts a great stress on the contacting parts causing failures. We, as furnace builders, feel that the best solution up to date is an air circuit breaker.

Our larger electrical manufacturers are giving very keen attention to this fact because of the rapid increase of large electric furnace installations.

A good deal has been said about the reactance in the circuit of an electric furnace. In the case of the smaller electric furnaces of, let us say, up to 3000 kva., the total impedance of the whole electric furnace circuit is usually too low to take care of the bumps and surges produced by the electric arc melting of cold steel scrap and it is therefore necessary to add to the circuit a certain amount of external reactance. This external reactance is usually incorporated in the transformer tank itself and the percentage of this reactance can be changed in a well designed furnace installation by means of taps, so that for a furnace having, let us say, 1500 kva. it would be possible to have external reactance equivalent to 20 per cent and 30 per cent at the will of the operator.

As the furnaces become larger the impedance of the total circuit increases, which is obvious, so that when we get to sizes of, let us say, 10,000 kva., the electric furnace designer's problem becomes a matter of keeping the inherent reactance of the furnace down to the absolute minimum, and where the power supply has been properly designed it is usual to have a total impedance of the transformer as low as 3 or 4 per cent with no external reactance.

In a general way when the power factor of a large electric furnace is somewhere between .85 to .87 it becomes a good compromise of electrical conditions for both the steel maker and the power company.

Any attempts to improve this power factor would tend to be a handicap to the power company, whereas

on the other hand if the power factor goes considerably lower than this then the steel maker is not getting the proper proportion of kw. into the furnace for the amount of kva. connected.

I would like to take this opportunity of pointing out one factor in electric furnace design which has not received sufficient attention and that is the safety of the secondary contactors.

Some 25 years ago practically all the electric furnaces operated on a secondary voltage of 90 between phases and it was not considered necessary to make any protection around the secondary flexible cables. With the rapid progress of electric steel making this secondary voltage has stepped up year by year until today we have electric furnaces operating day by day having a secondary voltage of 290 between phases and carrying currents of 30,000 amperes or more per phase. In most cases these flexible cables are still bare as they were 25 years ago. It is easy to see that this is not an ideal condition.

We are now tackling this problem in a way that will make even the secondary cables of large electric furnaces perfectly safe.

There has been a good deal of discussion in the electric furnace field regarding the highest voltage that can be used. In the case of large electrical capacity it would be the designers wish to keep these voltages as high as possible so as to keep down the current per phase for a given kva. capacity. It so happens that there are also certain metallurgical advantages to the use of high voltages, more particularly alloy steels. In my opinion, it is the development of surges and other electrical conditions which hold back more than anything else a still further step towards higher voltages.

R. H. LANG: We came here to learn; to find out if possible, the problems the furnace customers encounter with a view of determining how we might best render and maintain service to our industrial customers.

I was surprised to hear a manufacturer state that he contemplates building furnaces with a relatively low internal reactance. This would give utility men great concern. We are, of course, interested in maintaining proper service to our lighting customers as well as to our furnace customers. Generally the two services are supplied from a common station bus. If the manufacturers build equipment, the operation of which interferes with other than the furnace customers, I believe the utilities are in for plenty of trouble as the result of voltage variations.

I would like to ask a question: Mr. Black spoke of high capacity breakers. What is the rupturing capacity of the breakers used in connection with the furnaces, and what is the kva. capacity of the 25 ton furnaces?

L. H. FISTER: Whenever a paper is presented that deals with a part of your stock in trade, it becomes quite interesting, not only from a theoretical viewpoint, but from a practical standpoint as well.

The one impression I gathered as being of quite some importance to myself and which I want to pass along to you for what it may be worth other than the information conveyed by the paper itself, of course, was the method of handling this problem.

So far as the handling of any engineering problem is concerned, there would be no need of making any further mention of this point, if it were not for the fact that I cannot help but feel that those of us who have our nose so close to the grindstone so much of the time, are unaware of the fact that our perspective becomes somewhat obscured, and when it does, it involves the risk of misjudging the weight of certain important factors pertaining to the job at hand, with the subsequent risk of accepting equipment totally unsuitable from an operating standpoint.

To get back to my original statement, the method of handling this particular problem may, very briefly and very simply, as I see it, be divided into two parts. The first part dealing with the collection of accurate facts, the second part dealing with the interpretation of these facts. So much for that thought.

The only other thought I had in mind in connection with the operation of electric arc furnaces and I have no desire to extend this discussion so as to include all of the problems associated with arc furnaces, but I do want to make some mention of the problem of furnishing power, particularly to the larger type furnace, without impairing too seriously the voltage regulation of the main power supply system. However, after all is said and done, there are two factors that adversely affect the voltage regulation of any power system. The first is too much feeder and network line reactance, the second too little reserve in the flux capacity of the main generating units. If these two factors are properly taken care of, together with the use of some type of direct acting voltage regulator, then I believe good voltage regulation may be maintained.

In conclusion, I wonder whether Mr. Boehne would be kind enough to give us some idea of what takes place after the condenser has been charged to a maximum value and then starts to discharge.

CHARLES WASSERMAN: Most of my questions in relation to electric arc furnace operation have been answered in the discussion by the various members present, but I would like to know the actual percentage external reactance used in the furnace installation discussed by Mr. Black and the frequency of the system to which it is connected. Furthermore, what would be considered as good voltage regulation at the supply point for a 12,000 kva. single furnace installation as described by Mr. Brooks?

H. B. PECK: Theoretical analysis results in a value of reactance for furnace circuits that produces optimum current, that is, a value at which the kilowatt input to the furnace can be regulated to a maximum. If this value of reactance is changed, the kilowatt input decreases and I believe the power factor at optimum current is rather low. This, however, seems at variance with practical data. Many furnaces are run under conditions that produce high power factors and it naturally follows that the kilowatt input increases with power factor. I should like to know what relation or importance this optimum value of reactance has to actual furnace operation.

In present or future installations experiencing voltage surges where solution is sought by means of capacitors, it would be instructive to know whether the value of capacitive reactance is in any way dependent on the optimum inductive reactance.

N. R. STANSEL: There are two viewpoints of reactance in arc furnace circuits: that of the power system, and that of the furnace operation.

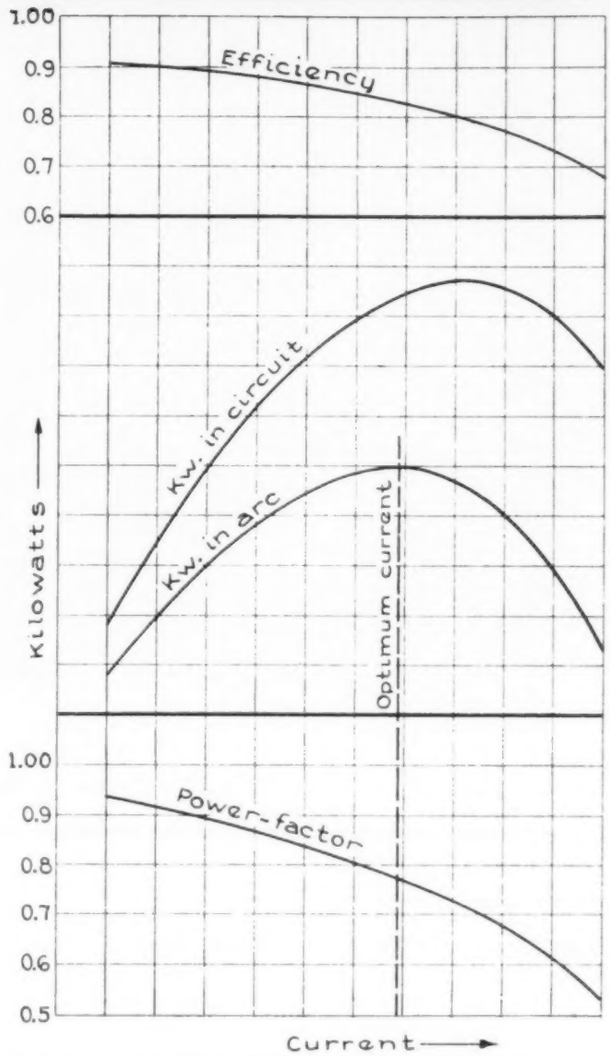


Figure A—Characteristic curves of arc furnace circuit.

I suggest first a reference to a paper, "Power Company Service to Arc Furnaces," by L. W. Clark, *Electrical Engineering*, November, 1935. That paper answers many of the questions of power engineers regarding this service.

The currents in a 3 phase arc furnace circuit are somewhat erratic both as to value and unbalance, particularly during the first part of the heat cycle. Transformers for this service are made for multiple voltage operation and starting the furnace with one of the low voltages is more or less common practice.

Reactance is used in arc furnace circuits to limit the current when an electrode touches the charge and to stabilize the circuit. The conditions relating to the power supply vary widely and the desirable value of this reactance is an individual study in each case. This study involves consideration of the size of the furnace installation, other electric apparatus on the same circuit, the short circuit kva. of the circuit, the demand factor, etc.

The reactance noted above is the total reactance between the furnace terminals and the point in the power system at which the voltage is held constant. Thus a furnace at the end of a long power line is a different problem from a similar installation near a large substation. Also one furnace alone is more of a problem in power supply than a number of such furnaces operating from the same circuit.

The operation of the furnace is dependent on reactance only to the extent of insuring continuity of operation. The stability of the circuit is much improved when the melting of the metal in the furnace is well under way; see the oscillograms in Mr. Clark's paper. At that time the circuit should be fairly well balanced and the power factor 85 to 90 per cent. Hence the normal reactance of an arc furnace circuit is considered to be 40 to 60 per cent.

The supplemental reactance that must be added in the form of a reactor depends on the amount of reactance of the conductors and transformer. The secondary voltage of large furnace installations is no higher than the voltage of small modern installations. Hence, the supplemental reactance required decreases as the size of the installation increases. The following table represents average present day practice.

Transformer rating, kva.	Supplemental reactance, per cent
Up to 1000	35–40
1001 to 2000	30–35
2001 to 3000	25–30
3001 to 4000	20–25
4001 to 5000	10–20

A reactor for this service has a number of taps so that it can be fitted to the best conditions of operation after installation.

The arc furnace circuit contains resistance and reactance, is operated at constant primary voltage, and supplies a unity power factor load. The characteristics of this circuit are shown in Figure A.

The value of the optimum current is,

$$i_{opt.} = \frac{e}{1.41x}\sqrt{1-\frac{r}{z}} \text{ amperes}$$

The corresponding value of the maximum power in the furnace is,

$$p_{max.} = \frac{3e^2}{2(z+r)10^3} \text{ kw.}$$

The power factor corresponding to the optimum current is obtained from the expression

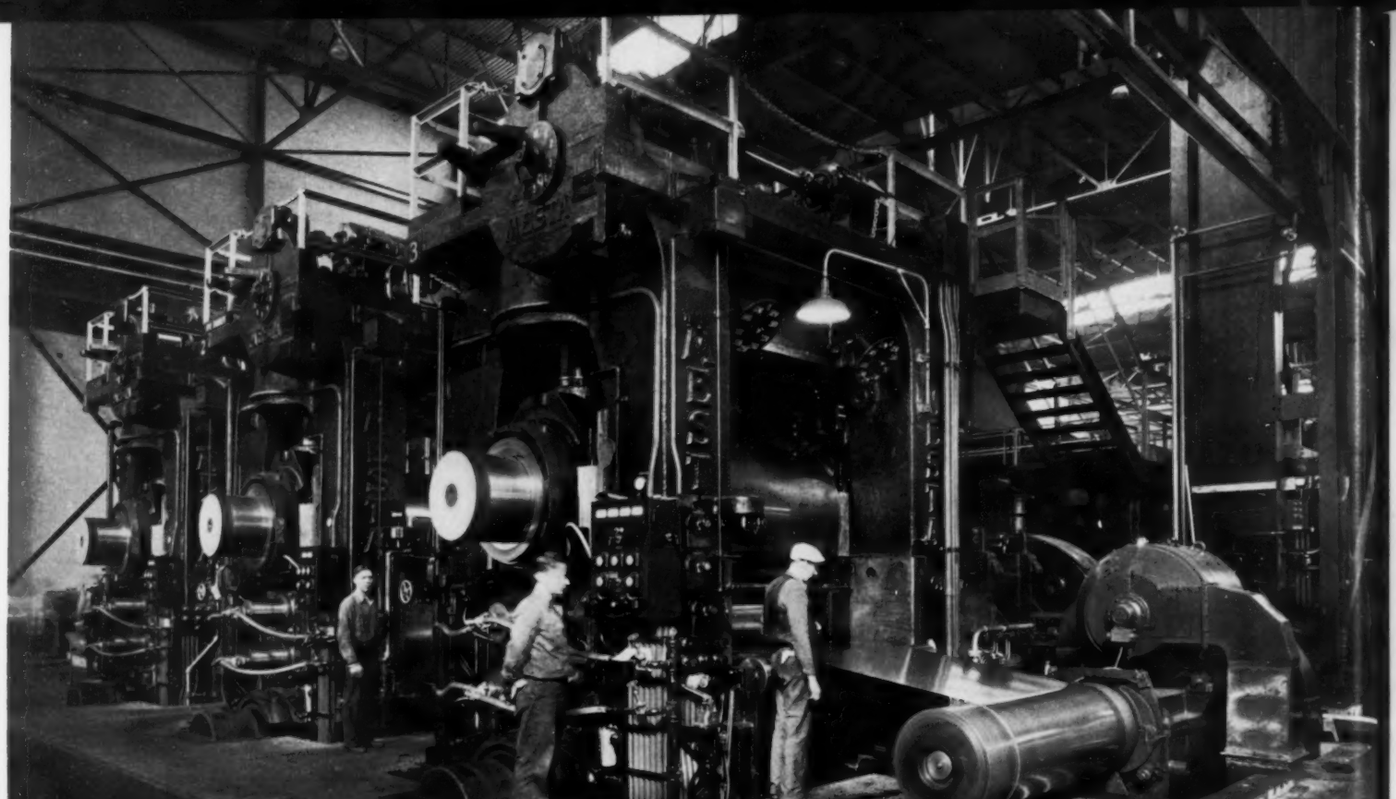
$$\tan \phi = \frac{x}{(z+r)}$$

e = applied voltage
x = reactance, ohm
r = resistance, ohm
z = impedance, ohm

All line to neutral values.

These values of current and power can usually be easily determined by trial towards the end of a heat when the operation of the circuit is stable and balanced. It is common fault of operators to assume that increasing current always means an increasing melting rate.

(*Please turn to page 103.*)



PROCESS OF COLD ROLLING

By T. C. Mayberry, *Assistant General Superintendent,*
Great Lakes Steel Corporation, Ecorse, Mich.

▲ AS far back as 1550 A.D. there was some cold rolling of metals for coins and medals. In 1747 cold rolling was first employed to polish the surface of sheets, and this practice was patented in 1783 in England. This industry really got its start in 1830 in Germany when high carbon steel wire was flattened by cold rolling. Between 1830 and 1855 there was rapid progress in America through the development of hard steel rolls, not comparable with those we use today but a step in the right direction. In 1859 cold rolled flat wire was used for hoop skirts and corset stays. Low carbon steel was cold rolled at New Britain, Connecticut, in 1871.

Within the last twenty years the cold reducing of strip has developed from a process used only for the small scale finishing of certain specialized products, to its status as the most important method of finishing all classes of flat rolled steel.

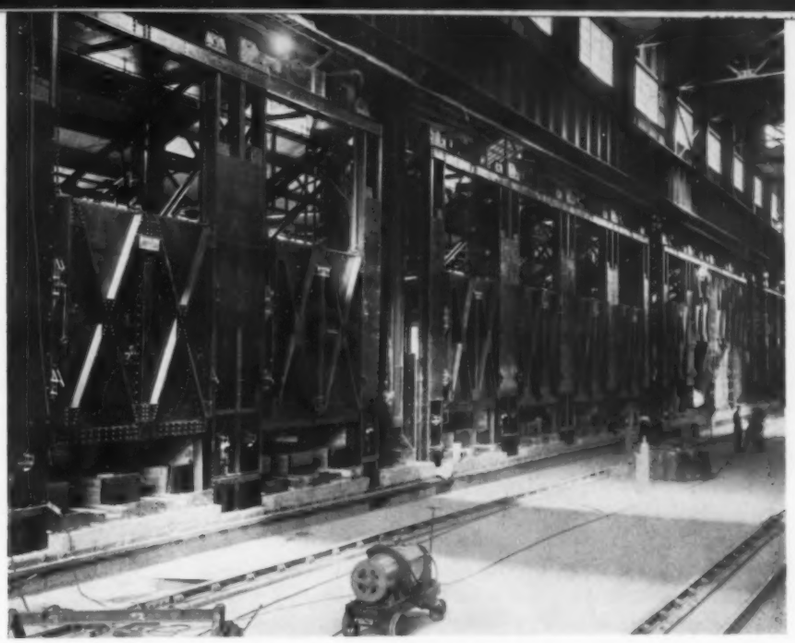
Before discussing in detail the individual operations involved in the manufacture of cold reduced sheets, let me briefly run through the flow sheet of this product at Great Lakes Steel Corporation. Molten steel, generally under .08 per cent carbon, is tapped from open hearth furnaces into ladles, and is poured from them into ingot moulds, and allowed to solidify. The ingots are heated in soaking pits, and rolled on the blooming mills into slabs which are surfaced by scarfing, then reheated, and rolled on a 96 in. continuous hot mill into bands of the required gauge, which are coiled. These hot bands are conveyed to the hot band storage where they are allowed to cool. They are then pickled in acid, cold reduced, sheared or side trimmed and recoiled, box annealed, skin roled, roller leveled, tested, inspected and oiled, bundled, wrapped and shipped.

CONTINUOUS PICKLING

Before cold reducing it is necessary to remove the scale that is formed by hot rolling. The continuous method is used by most of the mills today. A continuous pickling line consists of a decoiler, leveler, shear (welder and trimmer), or stitcher (some pickle lines have both stitcher and welder), No. 1 pinch rolls, looping pit, No. 2 pinch rolls, acid tanks, cold water rinse tank, hot water tank, hot air dryer, No. 3 pinch rolls, shear, oiler and recoiler.

This type of pickler is used for pickling coils only, the coils are delivered from the coil storage by a crane equipped with a magnet. Some months at Great Lakes Steel this crane delivers 27,000 coils to the picklers.

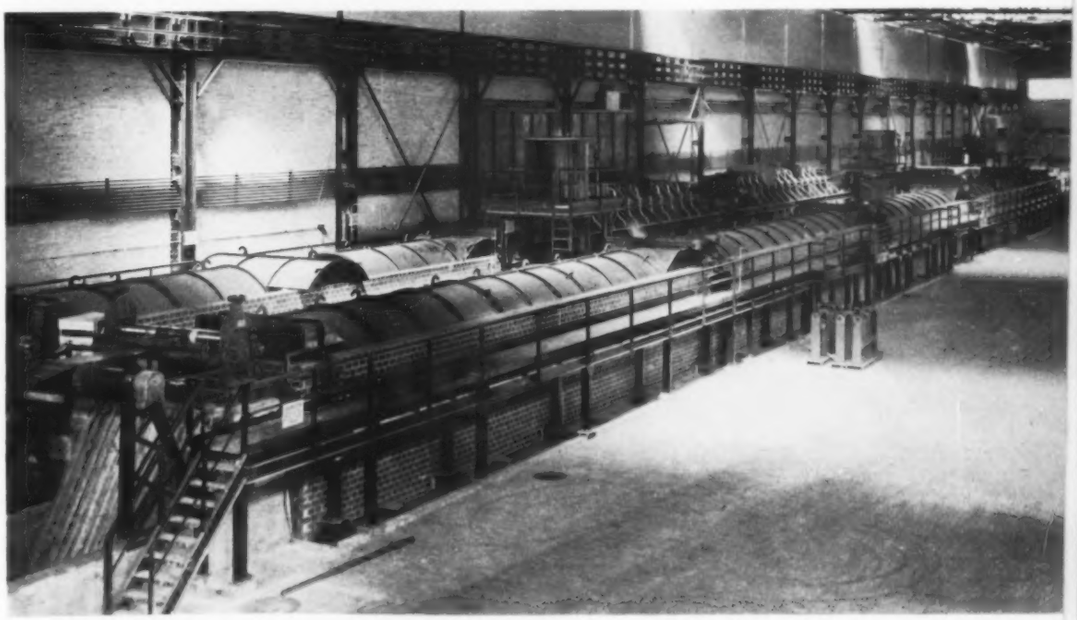
The coils are placed on a conveyor at the entry end of the pickler. These conveyor rolls are equipped with brakes so that the operator can release one coil at a time. The coil is placed on an "up-ender" that tilts



These five batteries of four double box length annealing furnaces are of the in-and-out type and are oil fired.

the coil down on its side. It then goes onto a trough section conveyor from where it is dumped onto a buggy or hoist to be centered on a mandrel. The buggy has power driven rolls that feed the coil end into the pinch rolls of the decoiler. A breaker roll is used for cracking the scale, and eliminating large cross breaks. There are many fine breaks which are not objectionable in the strip, but this breaking enables the acid to penetrate the scale more readily. The shear at the entry end is used to cut off fish tails and square the ends so the coils can be butt welded into larger size coils. Some customers want larger coils than can be coiled from the hot strip mill. The welded coils can be cold reduced, whereas stitched coils cannot, inasmuch as the stitched ends are overlapped and could not be reduced without marking the rolls. Welding small coils together increases tonnage on the cold reduction mills, flying shears, annealing and skin mills (when skin rolled in coils), and also results in less coil ends. There is some delay in welding and trimming, over stitching, on wide widths due to the coils being short. No. 1 pinch rolls are used to pull the strip through the trimmer or to pull the stitch through after being punched.

The looping pit is a large storage pit between the welder and the acid tanks. This enables the pickling units to continue operation while succeeding coils are being welded. No. 2 pinch rolls pull the strip from the looping pit into the entry end of the acid tanks. The diluted sulphuric acid is ordinarily maintained with an acid concentration of 8 to 12 per cent and at a temperature of 190 to 200 degrees F. The cold water rinse tank washes off the pickle solution and salt that carries over from the acid tank. The strip then goes through the hot water tank which is used to heat the strip so it can be dried by hot air and steam. No. 3 pinch rolls are located at the exit end of the hot water tank and are used to pull the strip through the acid and water tanks. The shear at the exit end is used for cutting out stitches and to cut the strip when the coil is the desired weight. The oiling machine consists of felt rollers that the strip passes through before entering the recoiler. After the strip is recoiled, the coil is forced out of the coiler by



This continuous pickler installed at the Great Lakes Steel Corporation handles strip at speeds of from 55 to 165 feet per minute.

an air cylinder onto the gravity conveyor which carries it into the cold mill building where it is weighed. At this point the coil is taken by a tractor to the cold reducing mill, or placed in storage.

COLD REDUCING

Great Lakes Steel has two 4-high, 3 stand tandem mills for cold reducing. These mills are 54 in. and 93 in. wide. The individual stands consist of two forged steel work rolls 20½ in. in diameter, and two cast steel back-up rolls 53 in. in diameter. Work rolls in the first and second stands are of a smooth bright finish, while work rolls in the third stand are given a grit blasted, or rough finish. The purpose of the grit blasted rolls is to mechanically roughen the surface in order to prevent sticking during annealing. When orders require a bright finish for use in chrome and nickel plating work, the No. 3 stand is supplied with bright finish work rolls.

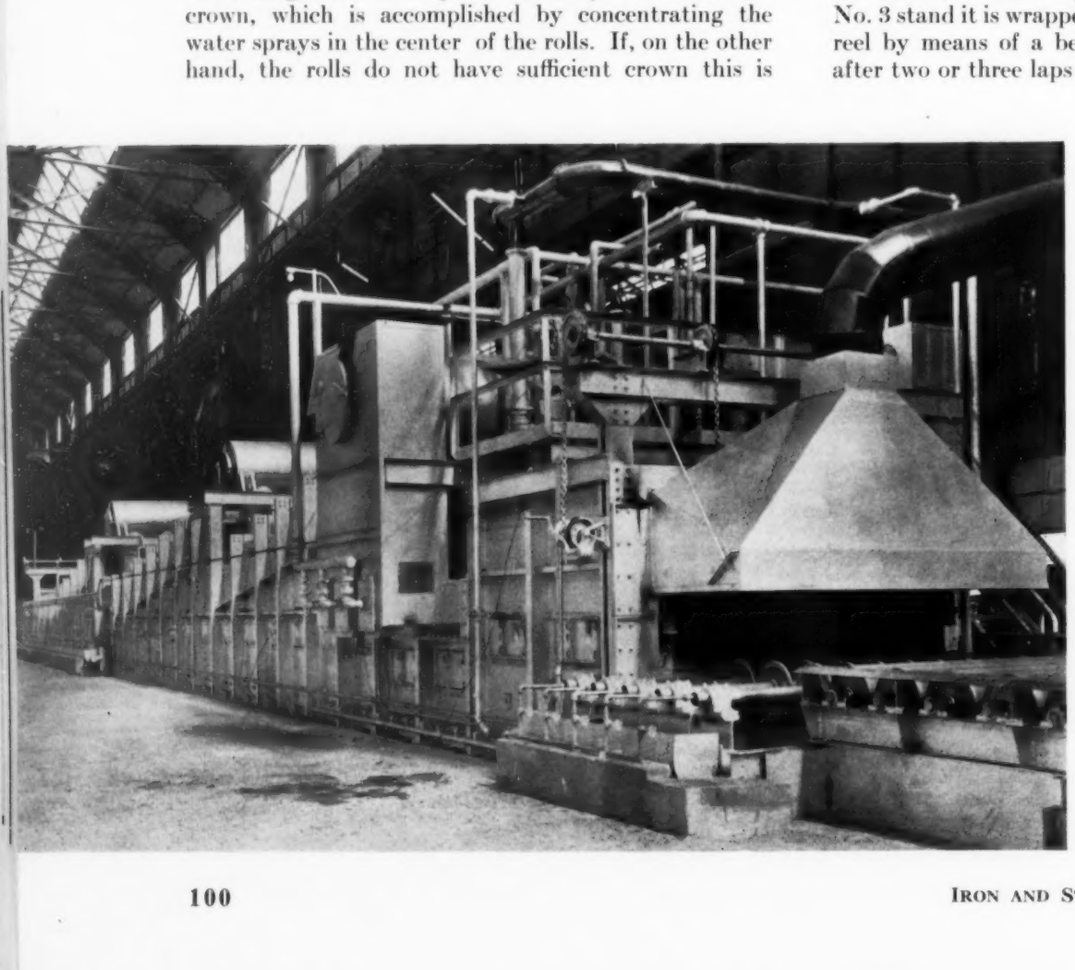
The cold reduction varies from 35 to 75 per cent, with an approximate average reduction of 60 per cent. This percentage may be apportioned between the three stands as follows: No. 1 stand 38 per cent, No. 2 stand 30 per cent and No. 3 stand 10 per cent.

As an aid to efficient rolling all mills are equipped with water sprays, which are used to cool the rolls, and assist in shaping them. Because of the fact that it is necessary to work a number of varying widths and gauges on the same set of rolls, these sprays must be in constant use. The application of such sprays may best be illustrated in the following manner. When slightly too much crown has been built up during the rolling of an order, for the succeeding order it may be necessary to reduce this crown, which is accomplished by concentrating the water sprays in the center of the rolls. If, on the other hand, the rolls do not have sufficient crown this is corrected by eliminating the water in the center, and turning it on at the ends.

Gas burners are also an important factor in helping to maintain roll shape. When more crown is desired the burners are adjusted so that the centers of the rolls are heated; and if a reduction in crown is advisable the burners are moved from the center to the ends of the rolls. Good practice on cold reducing mills requires rolling the widest width first, with a gradual narrowing down. Inasmuch as the individual orders rolled may vary from 12 to 28 gauge, and from 90 in. wide down to 24 in. wide it can be appreciated why the proper control of both gas and water is so important.

Flatness of the strip is essential, this being particularly true in the case of wide sheets. A buckle or twist will cause sticking in the box anneal, and pinchers, spreaders, floppers, and breaks when skin rolling. In cold reducing it is necessary to change work rolls before widening out, back-up rolls are changed after rolling 40,000 to 50,000 tons.

The entry side of each stand is equipped with a guide box. This box consists of adjustable bronze side guides, and hard wood bottom and top guides. The top guides can be raised and lowered by means of air cylinders. Coils delivered to the mill from the pickler are placed on an inclined ramp. The outside lap of the coil is bent back to a flat position, and held stationary while the coil is rolled into a coil box. The outside lap or coil end is then carried over the coil box, the top guide is raised, and after the coil end has been placed between the side guides it is fed into the rolls of No. 1 stand. The top guide is lowered immediately after the coil end enters the rolls. The coil is then entered into No. 2 and 3 stands in the same way. As the coil end comes out of No. 3 stand it is wrapped around a synchronized tension reel by means of a belt wrapper which is withdrawn after two or three laps are on the reel.



The normalizing furnace at the Great Lakes Steel Corporation is 140 feet long by 108 inches wide and has an 80 foot heating and a 60 foot cooling zone.

Between No. 3 stand and the tension reel there is an automatic micrometer which constantly indicates the gauge being rolled. We have found that placing another micrometer at the delivery side of No. 1 stand results in a more uniform gauge throughout the coil. This is particularly true since we must weld the front end of one hot band to the back end of another hot band, and cold reduction must eliminate as much of this original gauge variation as possible.

SHEARING

After cold reducing the next operation is shearing the coils into sheets and we call these units flying shears. A unit consists of a feed reel, slitter, leveler, shear, conveyor and piling rack.

Coils are placed on a sloping ramp at entry end of the line. A coil is rolled into a pit where it comes to rest on a saddle underneath which is a hoist. The hoist is raised so that the coil is elevated to the level of the feed reel head, which has a tapered cone, the end of which is smaller than the inside diameter of the coil, which automatically centers the coil, when the heads are run in, the hoist is then lowered leaving the coil hang on the cones and is free to turn with the feed reel heads. The end of the coil is fed into a pair of pinch rolls which in turn feed it through a set of rotary knives that trim the sides to the desired width and the side scrap goes down through a scrap channel guide where it is fed into a set of scrap knives consisting of one stationary knife and two revolving knives which are synchronized with the trimmer cutting the side scrap into approximately 6 in. pieces that fall into a scrap box.

The strip passes on through a leveler which flattens the strip and the leveler is synchronized with the shearing unit for desired length. There is a table between the leveler and rotary shear drums, the reason for the table is to convey the strip through the shear drums and so the strip may center itself after each cut. The top drum is one-half the diameter of the bottom drum, and carries one knife. The bottom drum carries two knives or one knife and a dummy when cutting long lengths. It is important when shearing sheets to length that the proper allowance be made, for subsequent elongation when skin rolling, to eliminate reshearing. After the sheet is sheared, it falls into a piling rack. When the pile has the desired number of sheets, the machine is stopped, and the back of the piling rack lowered and the lift is rolled out on a conveyor where there is a scale, after weighing, lifts are removed by a crane or a tractor and delivered to the annealing department.

Orders that ship in coils are processed through another unit, which consists of feed reel, slitter and tension reel. The coils are side trimmed only and rewound then delivered to the annealing department by a tractor.

BOX ANNEALING

In order to provide the right physical properties for forming and drawing, it is necessary to heat treat, to relieve the strains resulting from cold reducing, and box annealing is most commonly used. The sheets are piled on bases 40 to 50 in. high, depending on the width and the temperature of annealing. Thermocouples are inserted in the piles so the temperature can be known and recorded during the annealing cycle. After the sheets have been piled on the base, a cover is placed over them and sealed at the bottom with sand to prevent air infiltration and to aid in maintaining positive pressure of deoxidizing gas within the box. Annealing temperatures vary from 1150 to 1350 degrees F. and the soaking time varies from 4 hr. to 24 hr., depending on the product.

Deoxidizing gas is used inside the cover, thereby surrounding the sheets with a reducing atmosphere, which prevents oxidation of the surface. It is necessary to maintain this reducing atmosphere until the temperature of the sheets is cooled to approximately 250 degrees F., so as to assure the absence of any blue border which would be objectionable.

At Great Lakes a 75 ton charge of sheets to be annealed at 1280 to 1300 degrees sheet temperature requires approximately 44 hr. of firing to bring to temperature, and approximately 16 hr. soaking period, or a total time of 60 hr. in the furnace. From 72 to 80 hr. are required for the sheets to cool down to 250 degrees, then the cover is removed and the sheets taken off bases to be stored until cold for further processing.

Coil annealing is very much the same as sheets except the coils are placed in an upright position on the bases and can be piled 104 in. high in the new type coil furnaces. A coil charge of 75 tons annealed at 1280 to 1300 degrees coil temperature, would require approximately 40 hr. firing and 16 hr. soaking period or a total time of 56 hr. in the furnace. Approximately 50 hr. are required for the coils to cool down to 250 degrees, then the cover is removed and coils are taken off bases and stored until they are cold enough for skin rolling.

TEMPER ROLLING OR SKIN PASSING

Skin passing is the final rolling operation and is necessary for the following reasons: temper, flatness, and surface. The skin mills at Great Lakes are single stand 2-high and 4-high equipped with a conveyor table, hoist table, endless belt feed table, conveyor belt, roller leveler, floor conveyor and piling rack. Several lifts may be placed on the conveyor on the entry side of the mill from where a lift is pushed onto the hoist table and raised up to about an 80 degree angle. The sheets are peeled off and flopped one at a time onto the feed table which carries the sheet into the mill. The sheet continues through the mill, over a conveyor belt, into a roller leveler where it is flattened and piled. Skin rolling varies from ½ to 3 per cent and the surface may be bright or dull, depending on the customer's requirements. After skin rolling and roller leveling the lift is run out on a conveyor and it is then delivered to the inspection and oiling department.

A coil skin mill is equipped with a feed reel and tension reel. The feed reel holds the coil on the entry side of the mill. The tension reel is an expanding and collapsible reel on the delivery side, and is used to recoil the strip as it is being rolled.

When skin rolling coils, care must be taken so that

no cross breaks occur from unwinding and before the strip enters the rolls.

FINISHING AND SHIPPING

In the finishing department there are oiling machines, stretcher leveler, resquaring shears and sheet slitter. After the material, skin passed, has been tested and approved by the metallurgical department, the lifts are placed on a conveyor which is so arranged that it rolls down beside a feed table at the entry end of an oiling machine. The oiling machine consists of four felt rolls arranged in tandem of two pairs. There is an oil tank above the rolls in which a series of petcocks are inserted, and can be adjusted as to the amount of oil required. The sheets are inspected, fed through the oiling machine. The primes are put in one pile, and the rejects in another. When the pile or lift has the number of sheets required by the customer's specification, the lift is rolled out on a conveyor onto the finishing floor.

A sheet slitter is used when orders are processed double width. The stretcher leveler and resquare shears are used on material when the customer's requirements call for special flatness or size.

In the shipping department the lifts are supplied with the necessary skids, paper and bands. The lifts are then weighed and loaded into cars or trucks for shipment.

DISCUSSION

PRESENTED BY

L. A. ECKERMANN, Steel Plate and Shape Corporation, Detroit, Michigan

T. C. MAYBERRY, *Assistant General Superintendent*, Great Lakes Steel Corporation, Ecorse, Michigan

J. H. STEELE, *Superintendent*, Michigan Steel Division, Great Lakes Steel Corporation, Ecorse, Michigan

J. E. McBRIDE, *Vice President*, Palmer-Bee Company, Detroit, Michigan

A. D. BRODIE, *Superintendent*, 93 in. Cold Strip Mills and Galvanizing Department, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

W. R. MILLER, *Metallurgist*, Cuyahoga Works, American Steel and Wire Company, Cleveland, Ohio

E. H. COLLISTER, Arthur G. McKee and Company, Cleveland, Ohio

J. L. BUELL, JR., *District Manager*, Reliance Electric and Engineering Company, Detroit, Michigan

P. J. BOWEN, *General Foreman, Annealing*, Great Lakes Steel Corporation, Ecorse, Michigan

H. C. SMITH, *Assistant Chief Metallurgist*, Great Lakes Steel Corporation, Ecorse, Michigan

L. A. ECKERMAN: I should like to ask how much difference there is in the degree of flatness between the roller leveled and the stretcher leveled sheet.

T. C. MAYBERRY: A stretcher leveled sheet is much flatter than a roller leveled sheet because it is actually stretched to the extent that all loose metal, fluting, and lapper ends have been removed. A roller leveled sheet generally has some loose metal which will result in an oil can effect when formed if there is no draw. Then, too, a roller leveled sheet has a light corrugation at one end, which is known as the lapper end. The comparative degree of flatness can be illustrated by the following tolerances: The height of buckle for a stretcher leveled sheet, lying on a flat surface, shall not exceed ¼ in., whereas the height of buckle permissible for a roller leveled sheet is ¾ in.

J. H. STEELE: I was impressed with the rapidity with which this cold rolling development has taken place. I refer to the fact that sheet steel was first rolled in England in 1728 and that for 190 years there was no change in the system of rolling except as made possible by better power, better housings, and better rolls. Basically, the system remained the same for almost two centuries. Then in 1918, in about a five-year period, there was developed the double mill system in which sheet bar was broken down into breakdowns on one stand of rolls, and the breakdowns were finished on another stand or finishing mills.

In 1923 there started a cold reduction process, which in five years' time was perfected and became a reality covering the entire range of sheet steel. In 200 years the hot rolled sheet industry was born, grew into manhood, and practically died and was buried.

In the finishing operation the practice necessary with the hot rolled sheet has been found to be suicide for a cold rolled sheet. I refer to the fact that a hot rolled sheet must have a roller level pass before being cold rolled; while a cold reduced sheet cannot take a roller level pass until after it has been temper rolled.

The roller leveling of the hot rolled sheet made cold rolling without side strains possible and minimized the hazard of stretcher strains in the finished sheet. This practice would be ruinous to a cold reduced sheet.

We do not feel that the next 10 years will show the improvement in the cold roll process which we have seen recently. There will be refinements but the system will remain essentially the same.

J. E. McBRIDE: I am interested in knowing the maximum speed at which you can cold reduce the sheet after it comes from the pickler.

T. C. MAYBERRY: There are mills today that go 2800 ft., although our mills are 920 ft. for the maximum speed. There are mills, however, tin plate mills, cold reducing which go up to 2800 ft., I understand. I wouldn't say that is the maximum.

A. D. BRODIE: Our mill runs at 2000 ft. per min.; 3200 ft. is the maximum for cold reducing tin plate.

W. R. MILLER: I would like to ask Mr. Mayberry about this skin rolling, or final rolling. It was stated that you skin reduce the sheets ½ per cent to 3 per cent. I would like to inquire when you employ ½ per cent and when you employ the 3 pre cent reduction, and what effect does this variation have on the final sheet?

T. C. MAYBERRY: The ½ per cent skin rolling is done on the deep drawing jobs. After you get over ½ per cent, or possibly ¾, then you start to lower the ductility in the skin rolling operation. Possibly on the ½ per cent, the ductility is better than with dead soft sheets, but after you get past a certain point, I believe it is six-tenths of 1 per cent, then you begin to lower the ductility of the sheet, and when you go up to 2 per cent on fender jobs the breakage would probably be 50 per

cent, whereas on the same sheet if it is rolled about ½ per cent, the breakage would be possibly 2 per cent. The more a sheet is skin rolled, the lower will be the ductility. Skin rolling takes the drawing quality out of the sheet.

The reason we do go to 3 per cent, I might say to answer your question further, is that some shops want a stiffer sheet. The more you skin roll a sheet after it is annealed the stiffer the sheet becomes. Some shops are fussy about stretcher strains. When a sheet is skin rolled 2 or 3 per cent, it is not as likely to strain as with the lower percentage of skin rolling.

E. H. COLLISTER: I would like to ask Mr. Mayberry what tolerances they can maintain on the flying shears after the skin mill passing and also, I would like to ask him another question. I have seen a certain percentage of strip mill product going back to be normalized. I would like to ask him what the normalizing process is for, principally on the cold reduced product.

T. C. MAYBERRY: The answer probably is that the material was sent out and it had age hardened. When a sheet is skin rolled and shipped out, if it is not used up for two or three months, it might get to the point where it wouldn't make the part.

E. H. COLLISTER: I think, possibly, I stated that question improperly. The reason I said it came back was because the normalizing furnace happened to be in the hot strip finishing. Steel came from the cold mill to the hot mill to be normalized. Maybe it was box annealed before, I don't know.

T. C. MAYBERRY: If it had been box annealed, possibly the grain was too coarse. If you have a coarse grain and normalize it, you get a fine grain.

E. H. COLLISTER: That is after box annealing?

T. C. MAYBERRY: Yes. Take, for example, if you did box anneal and the grain size were too large, so that you couldn't apply it, you would have to retreat by normalizing to get the grain fine. Now, what was the other question?

E. H. COLLISTER: Tolerances that you maintain on the flying shear.

T. C. MAYBERRY: About ¼ in. is the figure we can hold to, although most of the sheets would be ⅛ in., but there is more variation when speed of the shears changes from slow to high. These variations occur at the beginning and end of each coil.

J. L. BUELL, JR.: In your annealing, I wonder if you are using fans at the bases for circulating the air. If you do have the fans, how much time is saved?

T. C. MAYBERRY: We do have the fans on the coil bases. I believe we can save approximately four hours per charge coming up to temperature.

P. J. BOWEN: We do have coil furnaces where we bring 75 tons up in 36 hr., due to the fact that we do have circulating fans that help to keep the temperature even from top to bottom.

H. C. SMITH: I enjoyed Mr. Mayberry's talk very much. Mr. Mayberry has on display the most distorted portion of a deeply drawn front fender. The small black squares are exactly one inch square. The spaces between the squares are the extent of distortion which these sheets had to withstand without breakage when drawn into this front fender.

Distortion is seldom equal both longitudinally and transversely. For that reason we have investigated many methods of measurement and are now of the opinion that wherever the average of the two diagonal distortions exceeds 28 per cent, when using 18 gauge sheets, we may be sure that only the very best drawing quality sheet will perform satisfactorily.

As an index it is more convenient to use a one inch diameter circle measuring the length of the axis of greatest distortion and averaging this figure with the greatest distortion at right angles to this major axis.

T. C. MAYBERRY: I have seen some .045 in. gauge reduced to .027 in. and .050 in. to .030 in. in drawing front fenders.

Black and Boehne Discussion

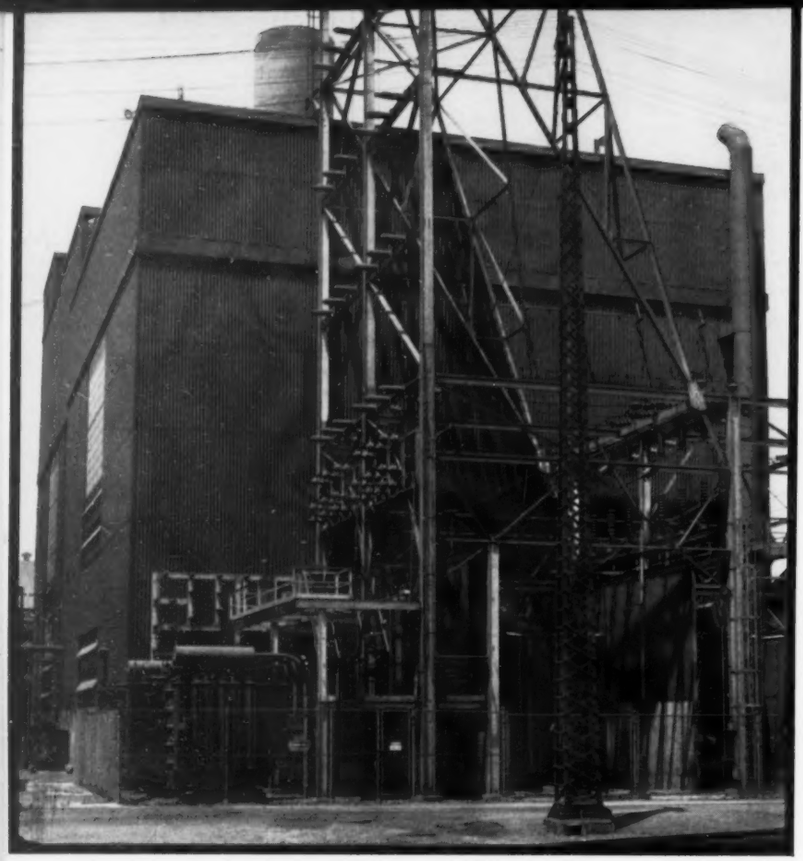
(Continued from Page 97)

E. W. BOEHNE: The three-phase protective shunt capacitor which was installed at the Bethlehem plant of the Bethlehem Steel Company in 1939 has now been in service almost two years. No trouble has arisen from the original complication due to surges of 70 kv. which were measured at that point. Other capacitor installations followed the initial installation at this plant.

Fundamentally, I believe this surge phenomena to be a current generated surge, that is, created by the sudden interruption of a small current. If this is true (the data presented in this paper tends to confirm this opinion), I feel that it should be pointed out that the phenomena is then practically independent of the circuit voltage. It follows therefore that the higher voltage installations are going to be less hazardous whereas the lower voltage installations are more likely to experience a higher "times normal voltage."

The observations seem to confirm my personal viewpoint that (1) more overvoltage stresses have been experienced on furnace circuits with lower primary voltage than on those with higher primary voltage; (2) over insulation of these lower voltage primary furnace circuits has proven a wise investment and (3) capacitor protection of the lower voltage installations when properly applied seem justified as a means of holding the surge to safe levels.

Although the presentation of surge data on a "times normal voltage" basis has its merits provided the primary circuit voltage is at hand, the warning should be posted not to quote these overvoltages entirely in terms of the "times normal primary voltage" without regard to the primary operating voltage. Such a practice would tend to be misleading, forming a too optimistic viewpoint for the low voltage circuits or a too pessimistic viewpoint for the high voltage installations. Until more is known of the phenomena the safest criterion is the absolute magnitude of the surges found.



New
POWER HOUSE
at
CARRIE FURNACE

▲ THE recently completed power plant at the Carrie Furnaces, Homestead Works, of the Carnegie-Illinois Steel Corporation was built to furnish electric power to the furnace plant and to the 44 kv., 25 cycle high tension network which serves corporation plants in the Monongahela River valley.* Including the new station, this system contains five generating stations with a combined capacity of 161,800 kw., all interconnected by a transmission system as indicated in Figure 1.

The new power plant, which consists of a 450,000 lb. per hr. boiler and a 32,000 kw. turbine-generator, constitutes the initial step of a comprehensive power plant which will ultimately be the corporation's principal power generating station in the Pittsburgh district.

The new plant is located centrally with respect to the blast furnace units which comprise the furnace plant, and it has been designed so that it can be extended to the north to accommodate additional boilers and turbine generators, and to the south to accommodate additional boilers and blast furnace blowing units.

The plant includes many features of design and construction which should be of special interest to steel engineers. Prominent among these are the following:

1. A power plant building utilizing steel construction to the maximum extent practicable.

2. Blast furnace gas and pulverized coal firing, controlled automatically to produce maximum combustion efficiency for any combination of the two fuels, and to favor the use of by-product blast furnace gas to the maximum extent.

3. Automatic control of the flue gas flow through the economizer and air heater to produce maximum heat recovery with reasonable draft loss at all loads.

4. A boiler specially designed to handle the frequent violent fluctuations of load resulting from rolling mill operation.

5. Circulating water discharge tunnel from the power plant to the river constructed without interfering with the use of the main railroad tracks serving the blast furnaces during tunnel construction.

STEAM GENERATING EQUIPMENT

The steam generating equipment consists of a four-drum steam generating unit, having a continuous rating of 450,000 lb. steam per hr. It is designed for 585 lb. per sq. in. drum pressure, and 750 degrees F. steam temperature at the superheater outlet. This unit contains 32,500 sq. ft. of heating surface, in addition to 12,780 sq. ft. of water walls, 7860 sq. ft. of superheater surface, 9300 sq. ft. of economizer surface and a 38,500 sq. ft. air heater. It is designed to develop full rated capacity either with blast furnace gas firing or pulverized fuel firing, or any combination of the two. The unit is guaranteed for a full load efficiency of 80.3 per cent with blast furnace gas and 85.8 with pulverized coal. A furnace volume of 28,000 cu. ft. has been provided so that heat releases are moderate with both coal and blast furnace gas fuel, running 21,000 and 22,300 Btu. per cu. ft. respectively. The boiler is of the four-drum type, with a completely water-cooled furnace and a dry ash hopper. An unusually complete complement of soot blowers has been provided as the blast furnace supply is only moderately clean and combined firing of gas and coal may be expected to cause slag tro uble. Al soot blowers are of the combination steam and water type and have been designed for use with steam at full boiler pressure and water at 600 lb. pressure. The draft equipment consists of two forced and two induced draft fans, each driven by constant speed motors and equipped with automatically controlled inlet vanes. The forced draft fans are rated at 325,000 lb. per hr., 80 degree F. air at 10.5 in. static pressure, and the induced draft fans at 600,000 lb. per hr., 550 degree F. flue gas at 10 in. static pressure. The induced draft fans are particularly noteworthy, being almost twice as large as the normal requirements for a boiler of the size they serve, because of the great volume of combustion products of blast furnace gas. The boiler feed water equipment consists of three 600,000 lb. per hr., 3600 rpm., 2010 ft. total head, turbine driven boiler feed pumps. Particular

*See "Transition from 25 to 60 Cycle Power in the Steel Industry," W. B. Skinkle, A.I.S.E. Yearbook, 1940, p. 149.

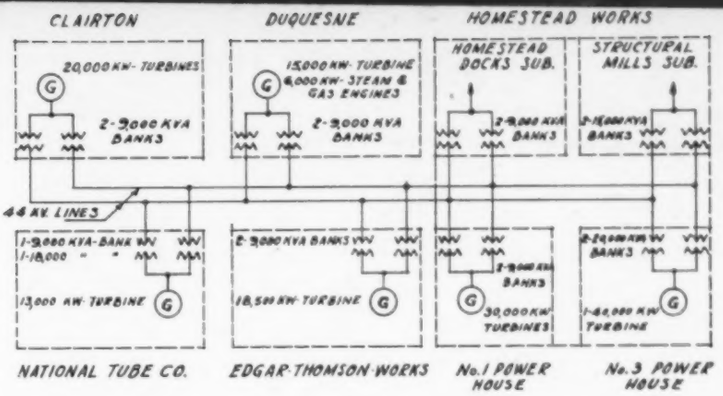


Figure 1—Single line diagram showing transmission system serving Monongahela valley plants of Carnegie-Illinois Steel Corporation.

attention was given to the selection of drive for these pumps and to the selection of turbine units having the highest possible efficiency, in order to meet heat balance requirements.

The main turbine is a single cylinder 1500 rpm. unit, designed for 550 lb., 750 degrees F., nominally rated at 32,000 kw. and driving a direct connected 40,000 kva. generator. The turbine-generator is erected upon a steel support. The turbine is designed for four stages of steam extraction for feed water heating. Accessory equipment includes four 4640 sq. ft. surface type generator air coolers, and duplicate oil coolers.

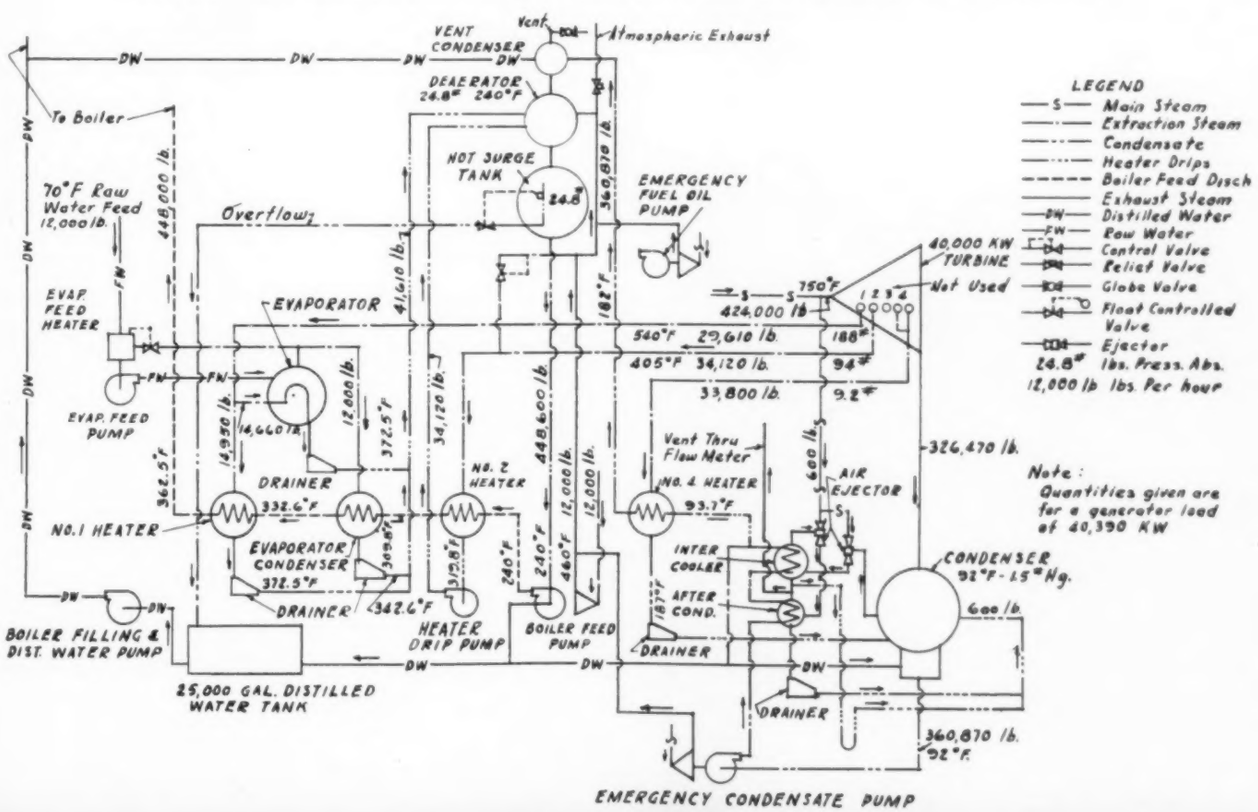
The turbine is served by a 35,000 sq. ft. two-pass surface condenser designed to maintain a normal exhaust pressure of 1.5 in. Hg, and having 1 in. diameter tubes of Admiralty metal. Condenser accessory equipment includes two motor-driven 20,500 gal. per min. circulating water pumps, one motor- and one turbine-driven condensate pump, each rated at 850 gal. per min., 210 ft. total head, and two twin steam jet air pumps. The circulating water pumps, designed for 42 ft. total head, are located in an existing pump house about 500 ft. from the new power house in order to utilize existing intake tunnels. The pumps discharge into a 60 in. cast iron pipe which has capacity for the present and two additional condensers of the same size. Provision was made for the future connection of additional circulating water pumps to the circulating water main.

The outstanding feature of the feed water system is its simplicity. The heat balance diagram, Figure 2, shows the flow of condensate through the system. Steam for heating feed water is obtained from three bleed points of the main turbine and from the exhaust of auxiliary drive turbines. The auxiliary turbines exhaust at about 25 lb. absolute pressure into a deaerating heater of tray type with a 500 sq. ft. vent condenser and a 13,500 gal. hot surge tank. Steam from the highest point of the main turbine (188 lb. absolute) may be delivered either to a 1270 sq. ft. closed heater, or to the station make-up evaporator, which contains 452 sq. ft. of surface. The latter discharges its vapor into a 569 sq. ft. condenser at 113 lb. absolute; steam from two other bleed points is delivered to closed feed water heaters containing 1380 sq. ft. and 1740 sq. ft. respectively at 94 lb. and 9 lb. absolute.

Condensate from the condenser hot well is pumped by the condensate pumps through the steam jet inter- and after-condensers, and then through the fourth stage heater to the deaerator. A hot surge tank below the deaerator provides a reservoir for the boiler feed pumps. These pumps discharge through the second stage heater, evaporator condenser, the first stage heater to the economizer inlet. At full turbine load the temperature at inlet of economizer will be approximately 360 degrees F.

The feed water system also includes storage tanks for

Figure 2—Heat balance and flow diagram of the new power plant at the Carrie Furnace plant.



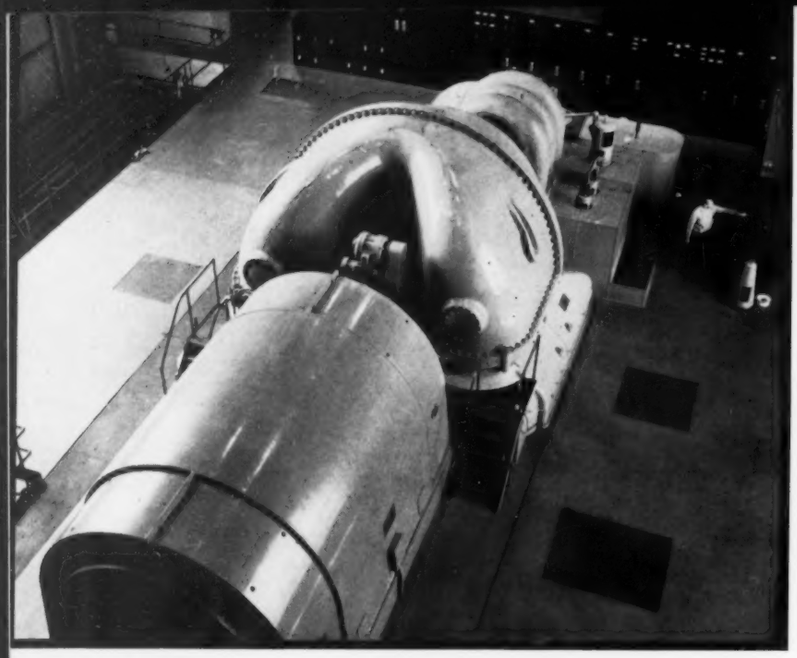


Figure 3—View of new turo-generator unit, which is rated at 40,000 kva., 13,800 volts, 25 cycles, and operates at 1500 rpm.

evaporated water reserve and make-up and draw-off provisions by which the system water surges can be handled without wasting condensate.

COAL AND ASH HANDLING EQUIPMENT

A track hopper has been installed adjacent to the boiler house to receive coal brought into the plant in hopper bottom cars. Coal is drawn from the hopper by a reciprocating feeder, passed through a crusher and discharged to the boot of a bucket elevator. This elevator discharges coal for the present through distributing chutes into the overhead coal bunker.

The coal handling equipment and bunker framing have been designed so that the elevator may discharge in the future to a shuttle conveyor which will distribute coal to bunkers to be provided in extensions to the north and south of the present boiler house. Coal is discharged from the bunker through gates to two automatic coal scales. These dischrage to small hoppers which in turn supply the feeders of the two duplex pulverizers. The boilers are equipped with dry type ash hoppers of about ten hours' storage of ashes at maximum coal consumption.

The ash handling equipment is of the pneumatic type. It delivers ashes to an overhead bunker located a short distance beyond the area reserved for ultimate plant expansion. The system has also been connected to the dust hoppers of the boiler so that soot collected at these points may be readily removed. In connection with the ash handling equipment, a dustless unloader has been provided and installed so that dust and ashes may be unloaded directly from the overhead bin into standard railroad cars without creating an objectionable dust nuisance.

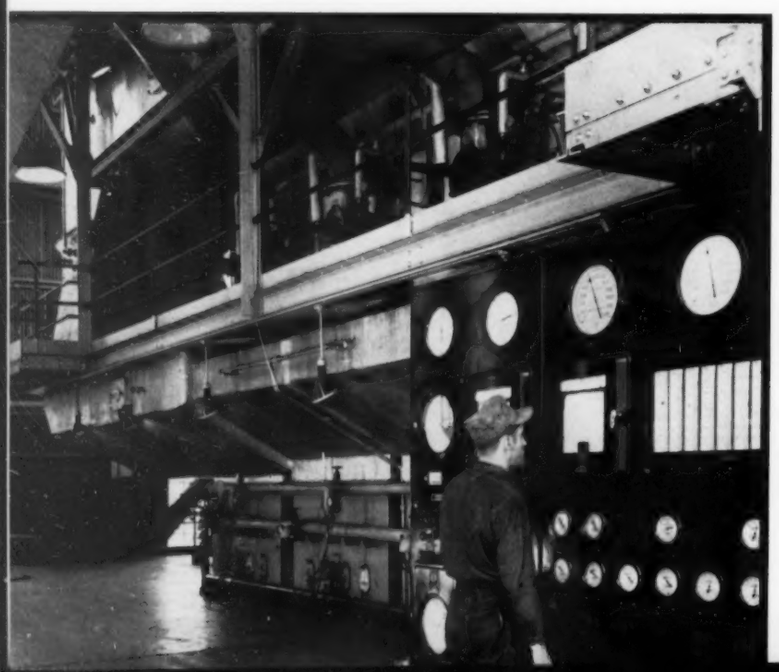


Figure 4—The four-drum steam generating unit operates at 585 lb. per sq. in. pressure, and burns blast furnace gas and pulverized coal.

ELECTRICAL FEATURES

The new generator is rated 40,000 kva., 13,800 volts, 25 cycles, and is provided with a direct connected exciter. The existing turbine-generator station at Carrie Furnaces contains two 15,000 kw., 6600 volt, 25 cycle, turbine driven generators. Power is distributed from it to the adjacent mills by overhead circuits at 6600 volts, and to the 44 kv. transmission system through two 9000 kva. transformers. The new unit has been tied directly to the 44 kv. transmission system by two 20,000 kva., 3 phase, step-up transformers, one transformer being connected to each 44 kv. line.

The 13,800 volt side of the 20,000 kva. step-up transformers are connected directly to the generator leads with oil circuit breakers on the 44 kv. side of the transformers.

Station service power is normally supplied from a 3000 kva., 3 phase transformer connected directly to the generator leads and stepping down the voltage to 2300 volts. A reserve source for station service power is provided by a 6600 volt cable from the existing steam station to which a 3000 kva., 3 phase transformer is connected for stepping down the voltage to 2300. Two 450 kva. transformers are provided for reducing the voltage to 230 volts for the smaller station service auxiliaries.

The new generator is controlled from the existing power station so that the operator can determine its loading and do the line switching for it as well as the two existing 15,000 kw. generators from the present benchboard.

BUILDING CONSTRUCTION

The ground upon which the power house building has been constructed consists of a fill of blast furnace slag and other hard material about 20 ft. deep, resting upon

a bed of river muck and a layer of gravel carrying down to bed rock about 60 ft. below the yard level.

The nature of the material between ground level and rock produced conditions which were especially suitable to the use of steel piling, and therefore piles of an H section driven through the hard fill and the muck and gravel to bed rock were used. The pile driving operations were highly successful.

The foundations, floors on ground and base walls of the structure are of reinforced concrete. The base walls extend to a height of approximately 10 ft. above the yard level, for flood protection, and steel flood doors are provided, ready to seal all openings in case of emergency.

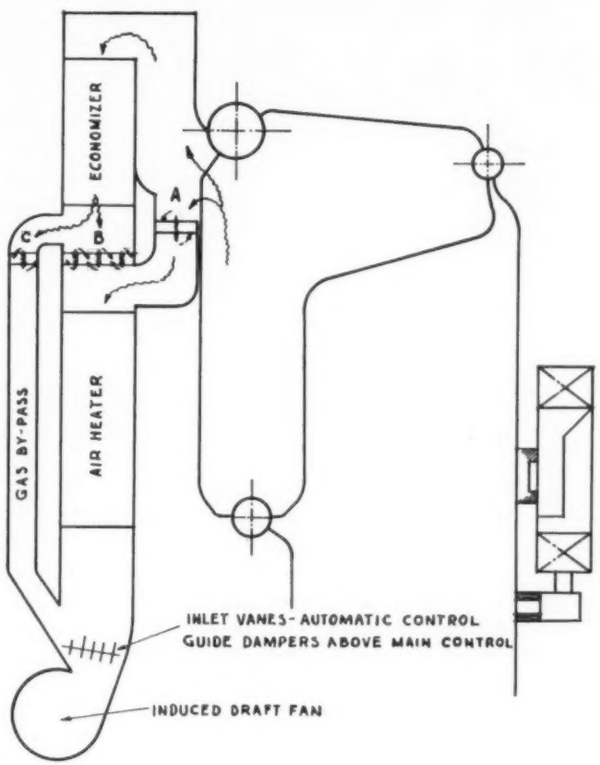


Figure 5—Sectional view showing arrangement of dampers controlling gas flow through economizer and air heater.

The building has a steel frame. The walls are of "sandwich" construction, consisting of two layers of corrugated steel with a layer of insulation between. The inner layer is galvanized, and the outer layer is asphalt and asbestos protected metal. All flashing, copings, belt courses and architectural trim are made of asphalt and asbestos protected metal. The windows and doors are of standard industrial type steel construction.

The roof is flat, and the roof surface is a smooth built-up asphalt membrane. Provision is made for washing down the roof from time to time, to remove the dust deposits from the nearby blast furnaces. There is a layer of insulation under the roofing and this is supported by a decking of deeply corrugated asphalt and asbestos protected steel, resting on steel purlins.

The interior of the power station is, in general, one large open room, but there are a number of small rooms for washrooms, toilets, locker rooms, offices, laboratory and special equipment. These are all enclosed in partitions of cellular steel, and have ceilings of the same material.

COMBUSTION CONTROL

One of the most interesting design features of the boiler plant is the fuel supply and combustion control system. The Carrie Furnace plant contains six large blast furnaces, and it produces a plentiful supply of surplus blast furnace gas.

However, the gas supply fluctuates with the blast furnace operations, and it is also subject to interruption hazards. It was therefore necessary to provide full capacity pulverized coal firing facilities in addition to the blast furnace gas burners. At present, this gas is consumed in gas engines which drive blowers and electric generators, and it is also burned under boilers for the production of steam for electric energy, but these uses will be largely supplanted by the new boiler and turbine.

At the outset the engineers undertook to design a combustion system which would make the most economical use of the fuels available, and at the same time to handle any load fluctuations which might be placed upon them. To accomplish this, preference is given to the use of blast furnace gas to the maximum extent that it is available, supplemented for higher load conditions with the necessary quantity of pulverized coal. The two fuels require different quantities of air for combustion and they produce radically different quantities of combustion products. Combustion control equipment has, therefore, been provided capable of varying the air supply, not only with load changes, but also with changes in fuel proportions. It has also been necessary to design the pulverized coal equipment to pick up the boiler load in case of any reduction or complete stoppage in the blast furnace gas supply.

GAS FLOW CONTROL

One of the differences between burning blast furnace gas and any other fuel is the large amount of products of combustion which must be handled. This becomes increasingly important in boilers of large steaming capacity and which include the extensive heat recovery apparatus required to produce high efficiency. Large gas quantities result in high draft losses, and in turn these necessitate large induced draft fan capacity and power consumption.

In order to reduce the draft loss through the new Carrie Furnace boiler with blast furnace gas firing at high loads and to correspondingly reduce the size and power consumption of induced draft fans, especially designed automatically operated damper mechanism has been provided to control the flow of gases through the economizer and air heater. This has been accomplished by providing ducts and dampers to by-pass part

of the flue gases around the economizer or air heater. The operation of these dampers, which is automatically controlled, is shown in Figure 3.

If the quantity of products of combustion is relatively small, as when burning solid fuel or small amounts of blast furnace gas, dampers *A* and *C* are both closed and all products of combustion pass first over the economizer surface and then through the air heater, damper *B* being wide open. This results in a maximum recovery of heat from the gases. When burning blast furnace gas, this method of operation is used until the load has increased to a point at which the draft requires full induced draft fan power. When that point is reached, the control mechanism operates a regulator which begins to open damper *C* and to permit part of the products of combustion to by-pass the air heater. As the load on the unit increases, damper *C* is opened wider, to maintain the predetermined conditions at the inlet of the induced draft fans. With further increase in load after damper *C* has been opened wide, it in turn operates two additional regulators which open damper *A* and close damper *B*. The opening of damper *A* permits gases to by-pass the economizer. These gases are hotter than those which have passed through the economizer, so it is desirable to pass them over the air heater surface in preference to the cooler gases from the economizer. It is to accomplish this that damper *B* is partly closed as damper *A* opens, the amount of closure being just sufficient to maintain a slight pressure differential across it. By maintaining this differential when by-passing gases around the economizer, it is impossible for these gases to by-pass the air heater also.

BOILER SURGES

Rolling mill operators are familiar with the violent fluctuations of load which result during the operation of large sheet mills.

At the Homestead Works, it was estimated that the large continuous plate mill operation imposes fluctuating load on the power system which increases the system load by as much as 30,000 kw. in a period of 10 seconds.

During normal mill operation, these sudden load increases occur at intervals of about one minute. They last about 15 seconds, in which period the load increases from a normal of 5000 kw. to a peak of 35,000 kw., and drops back to 5000 kw. During the remaining interval of 45 seconds, the load is expected to remain constant at 5000 kw. Any modern, large turbine-generator governing mechanism should be sufficiently responsive to follow these load changes without an objectionable lowering of system frequency, but this response must be accomplished by transferring load surges of the same magnitude to the steam generating equipment. In the design of the Carrie Furnace boiler steam output the engineers were given the problem of providing a boiler which would handle these surges in load quickly and efficiently. The problem has been handled in some steel mill power plants by installing a boiler to operate at a pressure considerably above the turbine throttle pressure with a reducing valve between it and the turbine throttle. This reducing valve operates automatically to maintain a fixed pressure at the turbine throttle and to vary the pressure in the boiler with load. Ultimately, the additional steam required during such surges must be generated either by flashing steam from the water stored in the boiler or by rapid fluctuations of fuel burned in the boiler furnace. At the Carrie Furances, no such reducing valve was installed. The turbine, its throttle mechanism, and all the piping leading to it have been built for a pressure of 600 lb., 50 lb. above the normal turbine operating pressure. At light load, the pressure at the turbine throttle will be close to 550 lb., and the turbine economy improved thereby. With increased load, a drop in throttle pressure will occur, while with a violent increase in turbine load, the steam pressure will be still further reduced and steam will be flashed from its stored water content. The pressure loss due to friction between the boiler drum and the turbine throttle will also be materially increased, resulting in an additional pressure reduction. The system has been designed so that the pressure at the turbine throttle will not be reduced below the normal pressure of 450 lb., even at the peak of the load fluctuation. In order to facilitate the generation of flashed steam, all parts of the boiler storage system have been made generously large. All water drums have been made substantially larger than the size originally recommended by the manufacturer as adequate for normal power house operation.

CONDENSER DISCHARGE TUNNEL

The construction of the circulating water discharge piping presented a formidable problem to the designing and construction engineers. The power house is located about 750 ft. from the Monongahela River, and the route of the discharge tunnel passed under several operating buildings and under the main railroad trackage serving two operating blast furnaces.

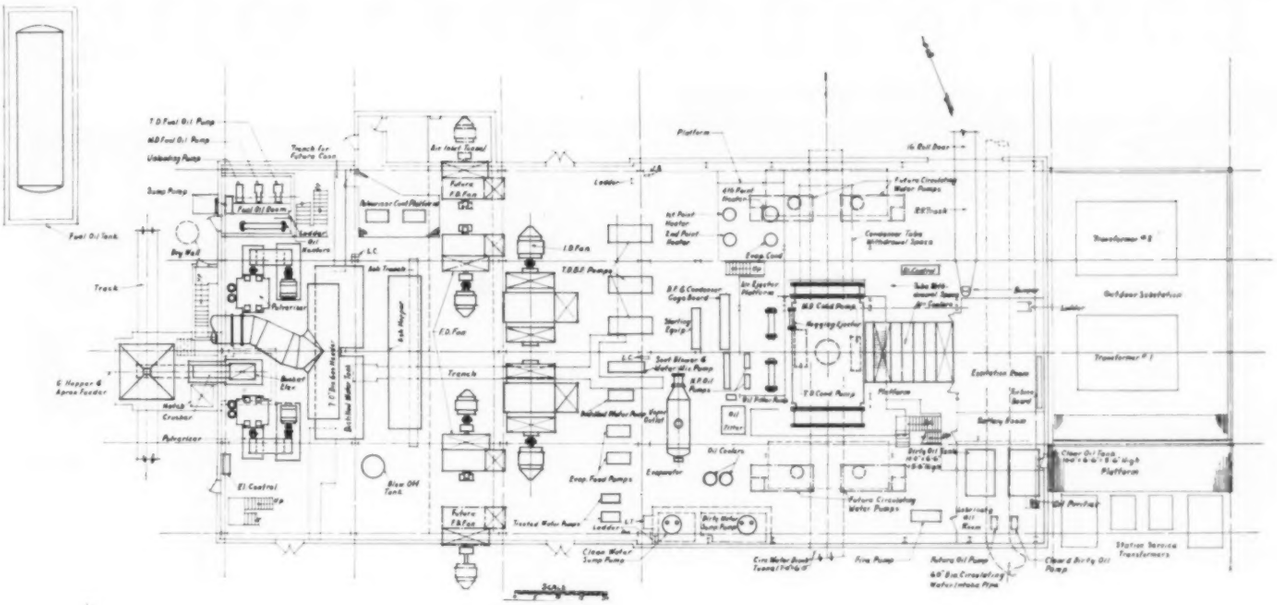
The tunnel, which is 7 ft. 6 in. in diameter, has been designed to handle the circulating water from an ultimate plant consisting of three turbine generators and six turbine blowers. In its construction, it was also necessary to minimize interference with blast furnace operation. This was particularly difficult because the area between the power plant and the river was traversed by fifteen standard gauge railroad tracks, all of them in use 24 hours per day for supplying raw materials to operating blast furnaces and in removing hot metal and slag from them.

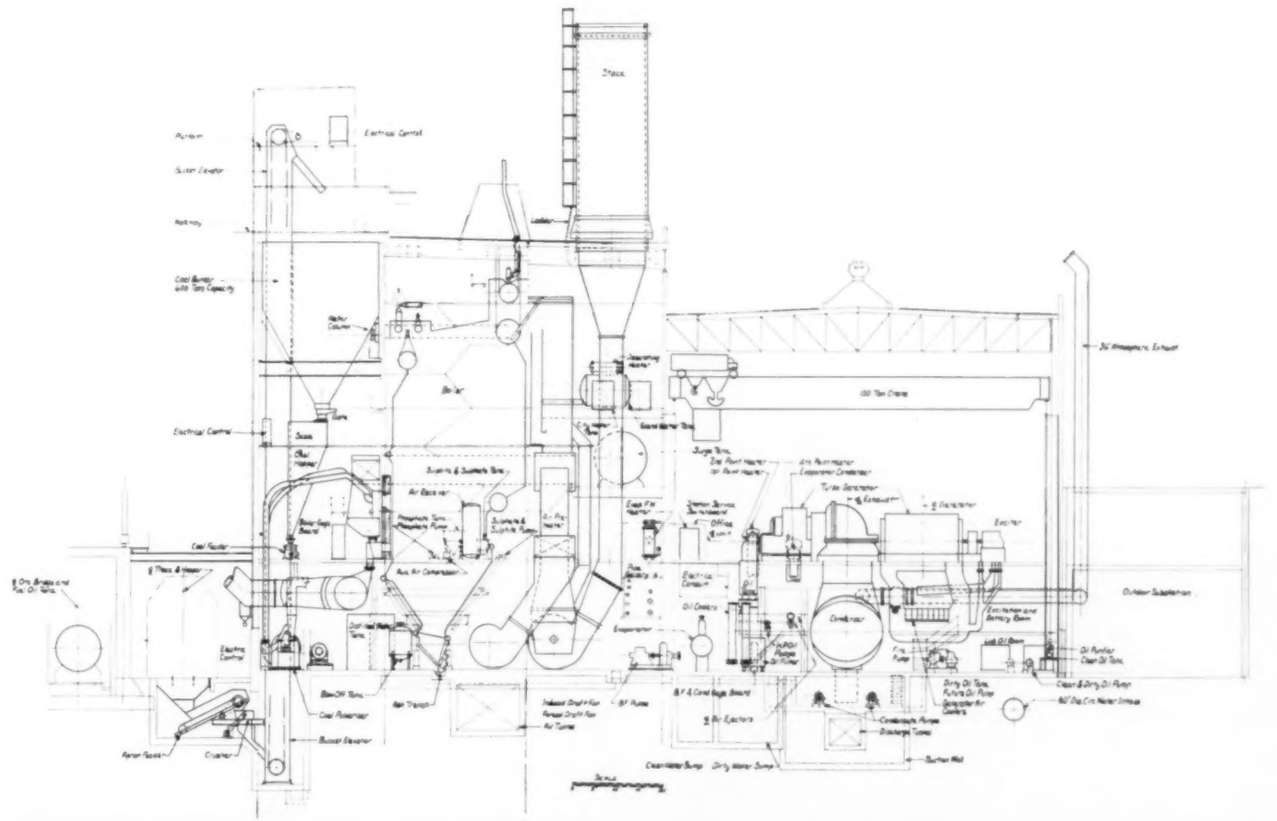
Because of the importance of maintaining all of these tracks in continuous operation, and because the proposed route of the tunnel also carried it under several large buildings, it was decided to resort to tunneling operations, and the entire 750 ft. was constructed in this manner. Beginning at the river, a portal was constructed in the main plant retaining wall and a cutting shield jacked through the clay and slag fill.

Excavation was accomplished by hand digging, and the spoil removed by small industrial cars running on a track which was extended as the driving operation proceeded. As the excavation proceeded, the tunnel was lined with steel liner plates forced into position by jacks and bolted together. When the excavation was completed, circular forms were constructed inside of the liner plates, and the space between the forms and liner plates filled with concrete forced into place through a hose by air pressure. The forms were then removed,

leaving a smooth tunnel lining of concrete about 9 in. thick.

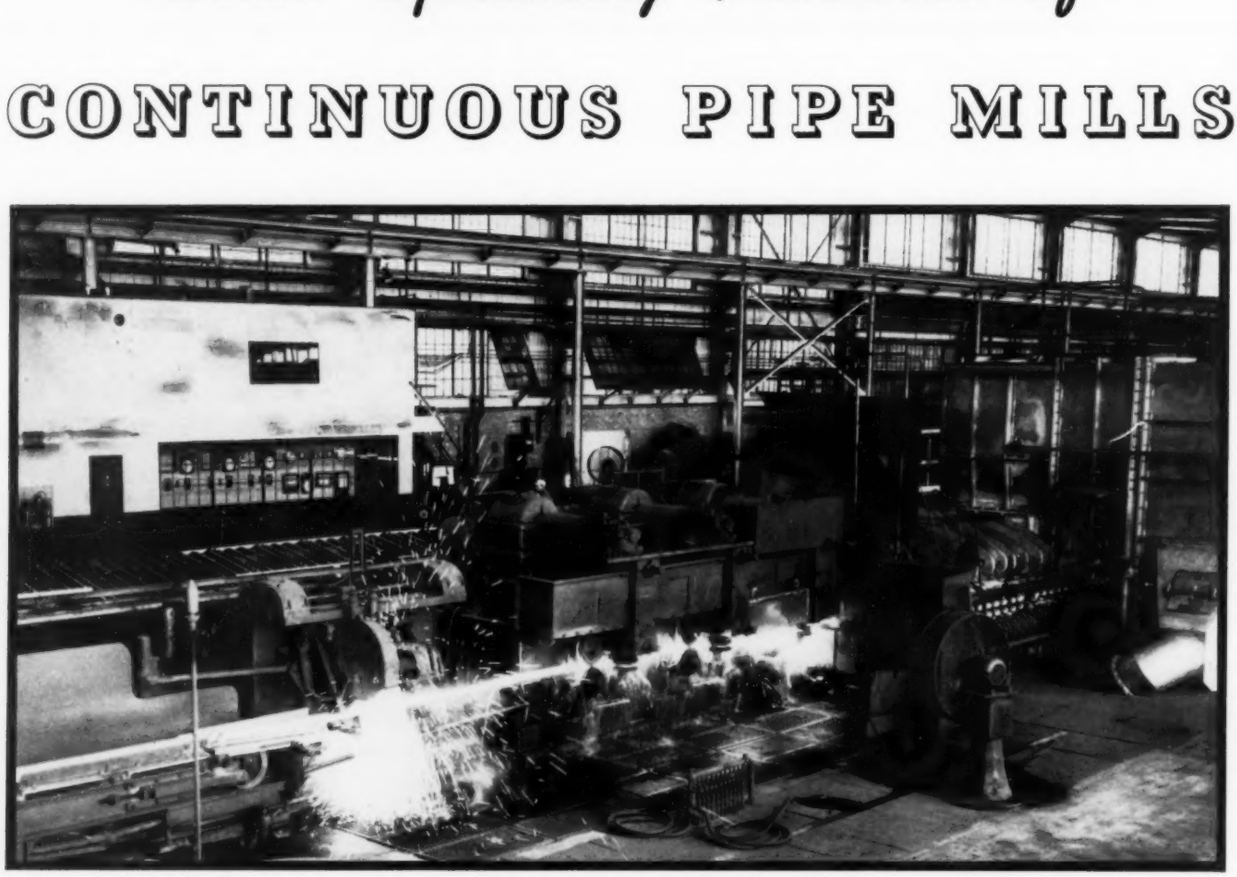
The entire tunneling operation was conducted almost without incident, although it was necessary to relocate several underground pipes which were encountered along the route. Several of these were plant sewers which were eventually cut off and connected into the new discharge tunnel.





Figures 6 and 7—General layouts showing plan and sectional elevation of the new power plant.

Some Operating Problems of CONTINUOUS PIPE MILLS



By L. J. Hess,

Superintendent of Pipe Mills, Bethlehem Steel Company, Sparrows Point, Maryland

Presented before A. I. S. E., Philadelphia Section, December 7, 1940

▲ THE paper previously presented by Messrs. Loux and Trebilcock before the Association of Iron and Steel Engineers (IRON AND STEEL ENGINEER, February, 1941) has covered the general history, construction and operation of continuous butt-weld tube mills very thoroughly. This is a continuous mill in the true sense of the word, for the raw material flows through the furnace and mills and is formed into pipe without interruption. Therefore the first consideration of the operating department must be to keep the mill running smoothly and at an even pace. The design of the loop table permits the skelp to stop in the flash welder long enough for the outside end of the incoming coil to be welded to the last end of the coil that has just been fed out onto the table. This is the only pause in the operation until the pipe is formed, welded and cut to length by the flying saw

But even the flash welding operation has a very limited time cycle especially when making the smaller sizes of pipe, and usually an error by the operator will result in a shut down. The fastest operation takes place on ½ in. pipe and the timing is governed by the following factors. The loop table is about 150 ft. long, but since it is not practicable to locate the flash welder too close to the furnace, the available loop that may be drawn into the furnace while the flash weld is being made is not more than 275 ft. Speeds through the furnace on this size pipe have been run up to 375 ft. per min., and a good average running speed is 350 ft. Thus the total time available for locating the last end of the coil in the welder jaws, feeding the incoming end of the next coil through the leveler and locating it in the welder, making the weld, allowing the weld to cool somewhat and finally shearing the flash is about 43 sec. The skelp is usually furnished with the ends sheared. However, occasionally one of these ends is not square, is turned down, or has a heavy burr. A shear is usually provided between the leveler and the welder to cut off such ends, but this is an extra operation and consumes precious time.

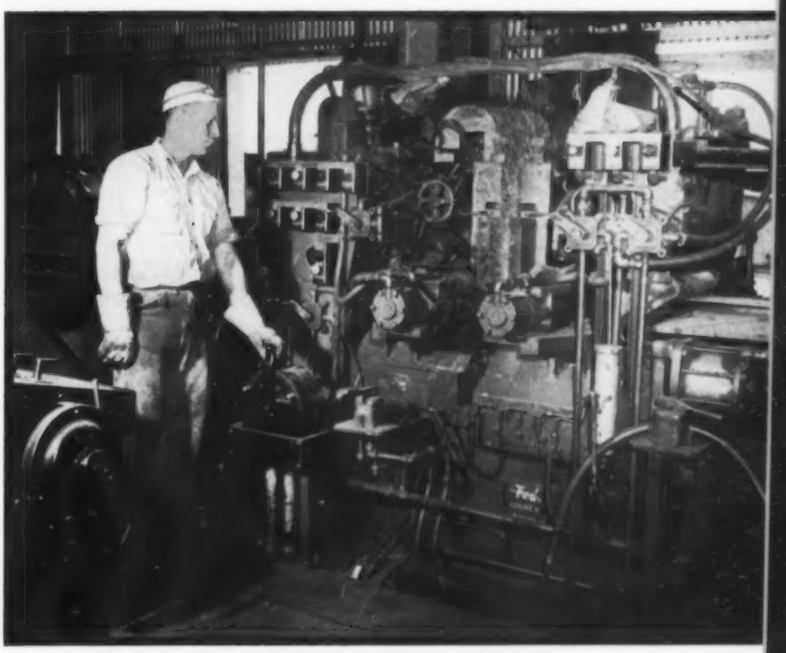
It is evident that any false move during the welding cycle will result in a slow-down at least, and on the

smaller sizes this means a shut-down, as it is usually not possible to cool off the furnace fast enough to prevent burning the skelp in two if its speed of travel is reduced. Experience has shown that about 80 per cent of all shut-downs originate in the flash welding cycle. Among the causes of shut-downs are faulty coils which telescope in the coil box, faulty coil ends, variations of width and thickness of skelp, dirt, tar, or grease on the coils picked up from car bottoms, incorrect setting of leveler when changing thickness of skelp from standard to extra heavy weight. The flash welder itself has a number of electrical and air operated controls, the failure of any one of which may result in a delay. The welder mechanism is subjected to a continuous shower of fine scale which is cracked loose by the leveler and as a result failures occur from short circuits and sluggish air control movements. One mill has installed a suction dust removal system connected to the leveler to remove as much of the loose scale as possible. Aside from the damage to the welder this dust carries out onto the loop table where it increases the sliding friction resulting in the skelp buckling as it is being pushed forward. Careful and constant inspection by the maintenance departments, together with intensive training of the operating crew are very necessary to produce the team work needed. It might be well to point out that the flash welder operator must be a man who is not easily flustered and who is quick with his hands and head. Younger men seem to be the best for the job.

The furnace itself is really the heart of the mill and presents the most difficult problems. As has been said in the previous paper it is simply a long overgrown blow torch. The refractories are subject to the intense heat of the burners with forced hot air injection, combined with the erosive action of high velocity gases carrying some finely divided iron oxide from the moving skelp. The last five feet of the furnace immediately ahead of the exit, must also resist the added erosion from the flying scale propelled by the air blast which is applied to the edges of the skelp as it emerges. As a result, the average life of the burner blocks and furnace lining in the hottest zone is about nine weeks. By that time not only are the walls eaten away, but the burner blocks are usually so badly out of shape that combustion efficiency is materially lowered and a rebuild becomes necessary. Some repair work is usually needed further back but this is of a minor nature. A continuous study is being made of this refractory problem and many different combinations have been tried. At present it is too early to predict what the final standard lining will be, or how long it will last, but it is felt that improvements are being made steadily. Operating practice seems to indicate that the furnace should never be allowed to cool off during the life of the lining, and best results are obtained by operating continuously from rebuild to rebuild. Some plants operate continuously, that is, 21 turns per week, while others operate 20 turns and keep the furnace hot during the idle turn.

From the rear of the furnace to the front, the temperature increases progressively. The scale, which drops from the skelp, must be removed from the bottom at regular intervals through doors provided for the purpose. Along the furnace up to the point where this scale becomes plastic from heat, it is easily removed with hoe and bar. But from there on, to the place where it becomes hot enough to run, it is in a sticky plastic state and is hard to handle. In the hottest zone the cinder and scale will usually run and can be tapped out, especially if some finely broken cast iron is thrown in from time to time. One furnace has been equipped with water cooled hearth plates in the slag holes in the hot zone so that the cinder will cool quickly and thus may be removed by breaking it up. It is understood that this has proved to be helpful.

The water cooled skid pipes, on which the skelp rides



View of modern continuous butt-weld pipe mill, showing discharge end of furnace, with welding rolls and hot saw.

▲

Flash welding of skelp before it enters the furnace makes the process a truly continous one.

through the furnace, have been a source of trouble due to wear. Not only does the wear finally result in leaks but the sharp edges which develop sometimes catch on the flash welds, causing skelp breakage. Various types of wearing surfaces have been applied to these skids by welding.

The welding mill itself has undergone quite a change in design since the original one was built. All of the smaller mills, that is those making pipe up to 3 in., have had six pairs of rolls driven from one motor through a gear train. Since the gear ratios are constant, the roll passes and relative diameters must be carefully maintained, or trouble from buckling and stretching will ensue. The larger later mills have been constructed with individual motors on each pair of rolls, each motor having an individual vernier field rheostat and load ammeter, all operated from a control system. Thus it becomes possible to adjust the individual speeds to compensate for differences in roll diameters, variations in pass sizes, inaccuracies in roll setting, and still be able to change the speed of the whole unit from one control point. Experience with this type of mill indicates many advantages, and it is felt that the extra investment is fully justified. Every effort should be made by the designers of these mills to provide ample protection from flying scale. Every crack and crevice soon becomes filled with a hard deposit of scale driven in by the air and steam jets that are a necessary part of the operation. These deposits seriously interfere with roll setting and constitute one of the worst features of the mill. Good practice indicates that complete removal of the cartridges every six weeks is quite necessary. The designers have also left the water and steam piping to the ingenuity of the purchaser. Too often insufficient clearance has been provided for these pipes and as a result, the small pipes clog easily and cause trouble. These pipes are also subject to severe erosion from flying scale and water and the design should permit renewal of individual water jets without shutting down, if possible.

The maintenance of the flying saw is without doubt the most difficult operating problem of the mill section. In order to estimate these difficulties perhaps a brief outline of the operation of the saw will be of interest. The carriage, whether operated by a crank or a cam, must make a complete cycle for each cut; that is, it must accelerate to mill speed, travel at mill speed a certain distance during the cut, decelerate to stop, reverse direction, accelerate and decelerate to stop on the return stroke. The usual travel distance is 24 in., of which 8 in. is used for acceleration, 8 in. for cut and 8 in. for deceleration. If we take the case of ½ in. pipe running at 360 ft. per min., the following timing cycle develops: The saw must accelerate from rest to 360 ft. per min. or 6 ft. per sec. in a space of 8 in. of travel, which results in an acceleration rate of 27 ft. per sec., must then travel for 8 in. at the rate of 6 ft. per sec., and then decelerate at the rate of 27 ft. per sec. The use of a cam instead of a crank motion permits the return stroke to be slower with less shock. From the above explanation it is easy to realize that the designers have had a very difficult problem. Uniform cut lengths are imperative and to cut within, say ½ in. plus or minus, the whole mechanism must function with a timing variation no greater than 1/72 of a second. When a machine has to operate within such close limits as this, while exposed to heat, water and scale, it is evident that there can be no let-up of the mechanical maintenance. Every part must function properly, must receive proper lubrication, and must be inspected at frequent intervals and replacements made at the least sign of wear.

The descaling and sizing mill gives some trouble unless roll setting is carefully carried out and maintained, and unless proper guides are used. It has been found necessary to redesign guides in some cases in order to facilitate rapid changes. Again on this unit the advantage of individual motor drives has been very apparent. Without question straighter and more accurate pipe could be produced if it were possible to adjust the roll speeds to meet the condition of the roll passes.

The use of alloy rolls has greatly increased the life of the passes, which in turn has decreased lost time due to roll changes. A definite roll change schedule is essential, as the operating crew always faces the temptation of longer operation for the sake of tonnage. Every effort should be made to line up the mill schedules with roll life to minimize delays. Sufficient storage space for unfinished pipe helps this situation materially.

The next year or two should see many improvements tried out and adopted by the various mills. It is believed that this type of mill has many possibilities which will increase both production and yields, and these will certainly be explored as time goes on. In closing I wish to emphasize that there has been complete coöperation both between the builders and operators and between the operators themselves. Information has passed freely for the ultimate benefit of the industry as a whole, and the various mills have always been open to the inspection of everyone interested. A spirit such as this can only result in a continued improvement in the product and operation.

DISCUSSION

PRESENTED BY

L. R. KELLS, *Sales Engineer*, Wellman Engineering Company, Cleveland, Ohio

L. J. HESS, Superintendent of Pipe Mills, Bethlehem Steel Company, Sparrows Point, Maryland

L. R. KELLS: There have been a total of ten of these continuous pipe mills built in the United States and Canada.

As Mr. Hess has discussed the problem, the maintenance on such a mill has been a troublesome factor. I think that the maintenance of refractories is one of the real problems. The first materials placed in a furnace of this kind lasted about one week. You can imagine replacing refractories in the furnace once a week. In an ordinary furnace, such as in a steel plant, the Btu

release per cubic foot is about 40,000 whereas in this furnace well over 200,000 Btu. are released per hr.

Bethlehem and others in the industry have done much to reduce this maintenance. I know of one mill that has operated as much as thirteen weeks, 21 turns per week, continuously, with a maintenance cost of 15 cents per ton of pipe produced. On the other hand the refractory maintenance at times has been more than one doller per ton.

I don't want to say much about the mill itself. The men at Bethlehem had much to do with refinement of the second mill, based upon their experience with the first mill. The hot saw on the No. 2 mill is based upon ideas developed by the chief engineer and his assistants at Bethlehem Steel, and the manufacturer of the equipment.

The size of the mill will, no doubt, be increased so that pipe larger than 4 in. may be made.

All mills for the making of pipe up to 3 in. have a single motor drive. You perhaps noticed the difference in design between the No. 1 and the No. 2 mills. Mills making pipe up to 4 in. diameter are heavier and are driven by separate motors for each pair of rolls. There are only two mills in existence using separate motor drives.

L. J. Hess: Mr. Kells talked somewhat about refractories. Of course we didn't have the experience with those earlier refractories as our furnace was built sufficiently late so we could take advantage of the knowledge of other people, who had such experience.

Perhaps you would be interested to know in that connection that our small No. 1 furnace, which now operates on 1 in., ½ in., and ¾ in. pipe only, has been in operation about one year. It has not had what we call a complete rebuild in that length of time. There have been a number of patch-work jobs on it, here and there—some burners have been replaced and some brick-work being replaced in the up-take, etc., but it is still running on the original brick-work in the majority of the furnace. This particular furnace is probably going down for a complete rebuild shortly, after having completed a year's campaign, operating practically continuously 20 turns per week, out of 21. We believe when we rebuild it this time, with the knowledge we have gained in the year's operation, we will probably succeed in operating it longer than a year, next time. However, that is purely guess-work on my part, and we just hope that will be the case.

Mr. Kells also spoke a little bit about the heavier mills and the larger sizes. You noticed that the mills were running on 3 in. pipe, and there were some pieces of 4 in. pipe laid up for your inspection, on a rack. Perhaps it will interest you to know, on the run of 4 in., on which that pipe was produced, we made 1250 tons at one rolling, and outside of minor slow-downs, we produced the entire 1250 tons, without stopping.

That is exceptional—it is not characteristic of the mill, which is a bit temperamental at times.

Items of Interest

H. E. Bodecker, formerly superintendent of maintenance at Crucible Steel Company of America, Pittsburgh, Pennsylvania, has been appointed superintendent of electrical and mechanical departments of Atlas Steels Limited, Welland, Canada. Mr. Bodecker first

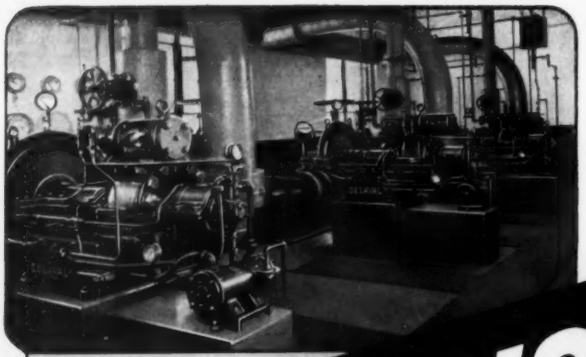
H. E. BODECKER

entered the steel industry in the tube mill electrical department at the La Belle Iron Works, now a part of the Wheeling Steel Corporation. After brief periods at the Farrell works of Carnegie Steel Company and the Middletown plant of American Rolling Mill Company, Mr. Bodecker became connected with Tennessee Coal, Iron and Railroad Company. Following two years in the electrical department of Wisconsin Steel Company and two years in electrical construction with Jones and Laughlin Steel Corporation, Mr. Bodecker joined the organization of the Crucible Steel Company of America at Pittsburgh, where he served for 15 years.

D. G. Baxter is appointed general superintendent in charge of the Copperweld Steel Company's Warren, Ohio plant. Mr. Baxter is a graduate of Ohio Northern University and is widely known in the steel business. He had previously been associated with American Steel and Wire Company, Pittsburgh Crucible Steel Company, Republic Steel Corporation, and the National Tube Company.

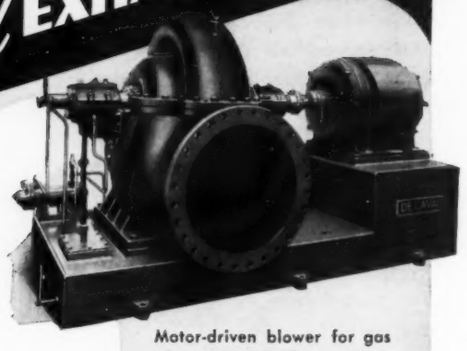
Carl E. Cromer has been appointed open-hearth superintendent, Granite City Steel Company, Granite City, Illinois, succeeding **Maj. J. W. Mills,** who will remain in an advisory capacity. Mr. Cromer, who has been associated with the company for about 20 years, has served successively as chief chemist, assistant metallurgist and assistant open-hearth superintendent.

James T. Fox has been made blast furnace superintendent for the blast furnace division, Koppers United Company, at Granite City, Illinois. He has been assistant blast furnace superintendent for the Interlake Iron Corporation, South Chicago, Illinois, for the past four years, and previous to that, was associated with the Inland Steel Company, Chicago.



Three turbine-driven exhausters drawing gas from holders and forcing it through condensers, scrubbers and purifiers, light oil scrubbers and meters to storage holders; 2280 to 5700 cfm. each against a maximum of 60 in. water column. Hydraulic governors provide for quick adjustment of delivery and pressure.

DE LAVAL BLOWERS, COMPRESSORS *and* EXHAUSTERS



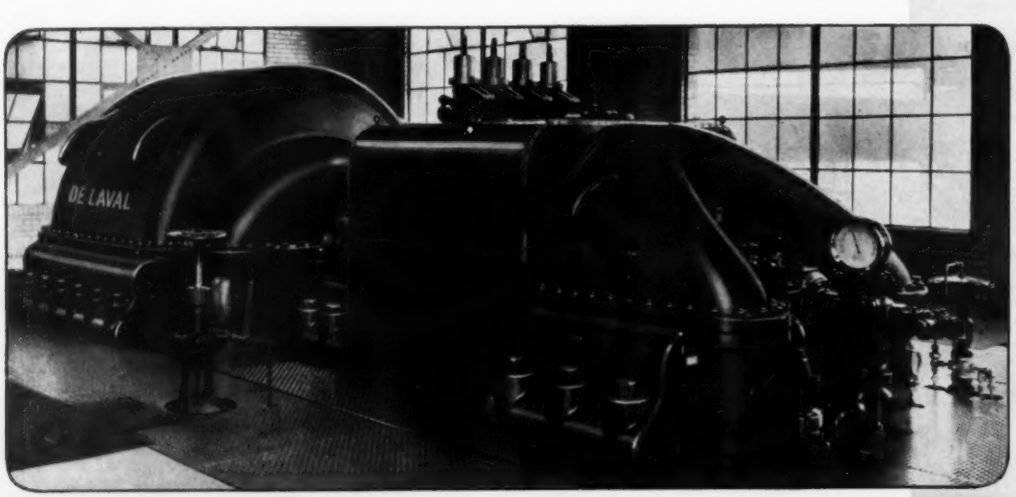
Motor-driven blower for gas plant; 26,200 cfm. against 54 in. water column.

are built for all volumes and for pressures up to 100 psi. They embody scientific and sturdy design, which contribute to continuous service and long life. Modern De Laval steam turbines driving these compressors are adapted for high pressure, high temperature steam, with segregation of moisture in low pressure stages to increase efficiency and reduce erosion, and with perfected governing systems to hold constant pressure, constant volume or constant mass flow.

By using De Laval double helical speed-increasing gears, standard speed motors are combined with high speed blowers or compressors, thereby avoiding the complication and expense of a greater number of stages.

State requirements and ask for Catalog F-3821.

Compressors in activated sludge plant; 3 rated at 47,000 cfm. each, and 2 at 25,000 cfm. each; all against 7.4 psi.



Turbine-driven blast furnace blower; 85,000 cfm. against 30 psi.

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MANUFACTURERS OF TURBINES — STEAM, HYDRAULIC; PUMPS — CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED FLOW, CLOGLESS, SELF-PRIMING; CENTRIFUGAL BLOWERS and COMPRESSORS; GEARS — WORM, HELICAL; and FLEXIBLE COUPLINGS

Abstracts of Papers

To Be Read At The A. I. S. E. Convention, Cleveland, Ohio, Sept. 23-25, 1941

THE DESIGN, CONSTRUCTION, AND OPERATION OF A BESSEMER CONVERTING MILL

By D. R. Loughrey

This paper treats of the broad subject of design, construction, operation, and maintenance of a bessemer converting mill, without attempting to describe in technical detail the many mechanical and metallurgical features of the process. It has rather been the purpose of the author to present a picture of the modern equipment of a converting mill as viewed from the operating man's standpoint, in the belief that such information would prove to be of value to an engineer who is confronted with the problem of designing a new mill or modernizing an old one.

The paper begins with the thought that the bessemer process, being difficult to control by scientific means, became subjected for many years to the various capacities and degrees of skill of the men handling it; this built up a reputation for non-uniformity and consequent unreliability of its product. However, this is not inherent in the process. By proper research and development of scientific means for control and other metallurgical improvements, the most objectionable features can be overcome.

In the layout and arrangement of a mill, the importance of other related units is brought out. The quantities of materials which can be expected to be handled are shown, indicating the importance of sufficient broad gauge railroad service.

The common objectionable features of different types of mill layouts are described with recommendations for the best design; features to be considered in specifying the blast equipment are enumerated and recommendations for capacities are made.

Because of the speed of bessemer operation, auxiliary equipment, such as mixers, cranes, converter bottoms, drying ovens, grinding pans, and other items, is of exceptional importance to a converting mill. For this reason the most useful types of such equipment are described.

In practically all literature pertaining to the operation of a converting mill, it has been customary to pass over the principal feature—which is, of course, the actual blowing of a heat of steel—with the general statement, "The vessel is turned down when the flame drops." Believing that any person interested in the bessemer process would like to know the various things which the blower is watching during the course of a blow, the visual standards which he has established in his mind for the temperature and endpoints, and his methods of obtaining those standards, these things are described in detail.

Finally, the pouring practice in the ingot molds, with the relationship it bears to the quality of the product, is discussed.

DIESEL ENGINE LUBRICATION

By D. N. Evans

No attempt is made in this paper to suggest the proper lubrication of diesel engines, but rather to touch on interesting portions of the Inland Steel Company's experience and practice with two and four cycle engines in diesel-electric and direct drive locomotives of the 60 and 100 ton class. Service life of the oil is discussed, and a control system for oil testing is outlined.

The practice of extending oil changes from annual inspection to annual inspection is discussed along with the use of large size absorbent type filters. Curves showing test runs are presented to illustrate the results of the yearly oil change.

General lubrication practice, filters, liners, rings and bearings complete the scope of this paper.

THE TEMPER MILL

By T. B. Montgomery

The application of power in the process of temper rolling, like practically all modern applications in industry, is based on the individual motor drive. In fact, the mill itself is a combination of entirely separate individual mill stands, tension rolls and reels each with separate driving motors, but so closely spaced together that the strip of steel can be kept under tension in passing from one of these units to the next and this tension controlled to the desired amount under all operating conditions. The discussion of the mill is based upon analysis of the separate parts and their relation to each other. Data are presented on:

1. Power requirements during rolling at a given speed.
2. Power requirements during acceleration.

Power requirements during periods of acceleration and deceleration are determined by reducing individual mill sections to equivalent flywheels.

Not only is this method of diagrammatic representation highly unique and successful, but it actually presents and makes clear the theory of rolling.

These several units of the mill then are mechanically linked together only by the strip of steel passing through them. Electrically, the several drive motors may have a common power source or parts of the mill may be supplied from a separate power source, whichever sup-

ply best suits the purpose of controlling tension during rolling.

The power connections of such a drive are shown and discussed. For purposes of analysis the mechanical link throughout the mill consisting of the steel strip, may then be thought of as a mechanical shaft connecting these units, similar to the shaft and bevel gears driving a train of rolls formerly used in many steel mill applications.

The shaft or strip has, of course, different stresses set up in and at different sections purposely, and rotors connected to the several sections. It should follow here that the sizes of the several motors are influenced by the required stresses to be set up in the respective sections to which each motor is connected.

Typical examples of stress distribution are given and curves shown of average power requirements for rolling steadily at a given delivery speed.

Each section of the mill, however, including its motor, has considerable inertia. In modern high speed mills, in order to take full advantage of the speed, a high rate of acceleration and deceleration is required. To each section of the shaft or strip there is an inertia which is reduced to an equivalent flywheel. These equivalent flywheels are of different sizes at the several sections of the shaft or strip, and unless the correct accelerating or decelerating torque (depending on the rate of acceleration) is applied at the corresponding flywheel, during a speed change, the stress in the shaft will be greatly altered and may exceed its ultimate strength.

Furthermore, the motor requirements for this flywheel effect alter decidedly the power requirements from those given for steady rolling conditions, where rolling is done at high speed. An example is worked out for a typical applications showing the amount of this effect

The reels present a different problem in flywheel effect from that of the other sections of the mill in that the size of their equivalent flywheel changes with the amount of steel on them. The value of this change is shown in graphic form and methods for controlling the accelerating torques to the correct amount as the flywheel sizes change is described.

Finally since tempering is accomplished by a combination of roll pressure and tension in the strip, the effect of this combination by virtue of the analysis of the motor power requirements in each section of the mill is pictured.

This then gives a picture of the action transpiring in each section of the mill which results in the elimination of stretcher strains during the subsequent forming of the steel.

MODERN DESIGN OF ANNEALING COVERS

By Lee Wilson

Ten years ago the cry was—where can we buy a good sheet annealing furnace? Today the question is—*which is the best?* This is progress which the steel and furnace industry can be proud of.

Such progress is only brought about by coöperation and competition. Coöperation between the user and manufacturer, and competition between the equipment manufacturers. As a result of this American way of doing things, a man can buy from any one of four companies an annealing furnace with utmost confidence that he will get a good practical furnace that will do a good job for him. His only problem is, which furnace meets his needs the best. It is just the same as choosing an automobile—they are all good, but some one make suits you best.

The three popular types can be classed as follows: portable bell radiant tube; portable bell electric; and in-and-out direct fired.

In addition there have been experimental furnaces of the portable direct fired type. Each type has its place.

Portable bell radiant tube furnaces fill the need of the man wanting quantity production of high quality material at a low cost in the temperature range up to 1800 degrees F.

Electric bells fill the need for high quality work above 1800 degrees F.

In-and-out furnaces are used when furnaces can be placed in buildings of the lean-to type more advantageously, from a space and first cost standpoint.

Direct fired bells that have been built experimentally have not yet proved of any advantage and have several inherent handicaps.

The future developments in annealing will probably be along three lines—

1. Improvements in present designs.
2. A change to strand or continuous annealing.
3. A moving of the heating source from the outside of the inner cover to the inside where it will be in direct contact with the work.

Considerable work along all three of these lines is going on by various companies today and will be discussed in detail.

ADVANCED METHOD OF ARC WELDING

By E. W. P. Smith

In the present national emergency, reduction in time in the production of any product is of vital importance. If along with this goes cost and weight reduction, consideration of methods to produce these results is essential. These results are obtained to a maximum degree by the study and application of advance methods of arc welding, such as the use of larger electrodes, positioning, use of higher current, use of proper equipment, as is necessary for even lower costs to be obtained, as welding is in competition with other methods and must keep ahead—simple and easy to apply. Following is a study of the methods.

Welding is a localized consolidation of metals, resulting in a joint. The object of welding is to make joints and assembly parts into a completed whole. The joint has certain shape, depending upon the design, fabrication requirements. Metal is deposited by the electrode in this required shape. One kilowatt hour at the arc is equal to one pound consumption of the electrode, or, under usual conditions, two-thirds of a pound of metal deposited in the bead. Inasmuch as the thickness of the plate is fixed by the design usually, and so also is the

size and shape of the joint, that is, the size and shape of the deposited metal, then the weight of the deposit divided by two-thirds is equal to the kilowatt hours required at the arc. Kilowatt hour is equal to the voltage times the current times the hours, divided by a thousand, so for a given kilowatt hour, to decrease the hours or time, the amperes must be increased, that is, to increase the current and the electrode size. Information with reference to current and electrode size and deposit rates is exceedingly instructive. The distortion resulting from welding will be considerably less due to the fewer number of passes. Increase in electrode size, that is, the speed of production, is a matter of the plate thickness; the joints, type, positioning, selection of the joint depend upon load conditions. Position may be selected or required by the design, but it should be determined for maximum speed, the selection of the electrode depending upon the type of bead required. Positioning is of two types, the static and moving. Both of these have a very decided effect upon speed of production. The equipment involving a welding unit should have high efficiency mechanically, with resulting lower power costs; high welding efficiency, that is the production of a high rate of deposit of materials, the controls being such as to permit the adjustment of the machine to meet the arc requirements. With this, of course, is tied in the electrode and the time. Total time is equal to the idle time plus the operating time. The idling time is a power loss and therefore an expense item, and no production obtained. The operating time is production at some cost.

Each factor outlined above may be considered for both automatic and hand welding, and a general study of these factors will result in the production of lower costs, higher speed.

SUBMERGED COMBUSTION HEATING FOR PICKLING BATHS

By W. G. See

Although there is much current discussion about submerged combustion, this is due more to recent developments than to its newness. Actually it is a development which extends back to 1887 when Brunler developed the first submerged combustion burner. Because this burner was not acid resistant and not automatically ignited and controlled it was impractical from a commercial standpoint.

Eleven years ago the desire for a submerged burner which would be practical for use in pickling prompted a man well versed in steel mill practice to begin experiments with a burner of this type. In order to duplicate the corrosive atmosphere and rough treatment to which pickle room equipment is subjected all test work was done in a pickle room under actual working conditions. From the first experimental burner the results were amazing and proved without a doubt the practicalness of equipment of this type.

The system consists of a control assembly designed so that the operator or watchman has only to press a button to put the entire unit into operation. The burner might be classed as a nozzle mixing type with no possibility of back firing.

The burner plate is located beneath the solution level to insure the cooling of the combustion chamber by the surrounding liquid. The tubular combustion chamber conducts the heat and products of combustion down to and across the bottom of the tub where they are vented and distributed to give the rate of agitation desired.

Submerged combustion can be used to advantage in many applications of solution heating. It is especially adaptable to the rapid distillation and concentration of liquids. It is an excellent water softener and can be used to heat and agitate many types of cleaning solutions. One of its most practical applications is pickling.

With submerged combustion, the products of combustion are exhausted directly into the solution. This creates a terrific agitation and the pickling solution, generally dilute sulphuric acid, is agitated and moved about the vat at a rate which would be extremely difficult to achieve mechanically. As a result the average pickling time on various grades of steel is reduced 40 to 70 per cent of former practice if the operating temperature is held the same as it was with steam. The agitation also serves to keep the temperature extremely uniform throughout practically any size tank.

Direct firing has other advantages, lower pickling temperatures, lower heating costs, more uniform pickling, and evaporation of the water from the pickling solution. This latter point is becoming more important with the passage of stream pollution bills. It means less diluted acid to haul away to pits or to reclaim in costly systems. One plant in like production years cut their acid bill from $22,418 to $10,145. Another important advantage is more production with the same pickling room equipment if handling facilities are adequate or the same production from less tanks. Production increase in one wire department was 296.2 per cent over open steam jet heated tanks.

It is extremely difficult to visualize the terrific agitation created by submerged combustion without seeing a unit in action. It would be equally difficult to believe that an increase of 50 to 80 per cent in production and a drastically lower pickling cost can be achieved by their use if it were not for the fact that many installations are substantiating these amazing figures in actual practice.

ORE BRIDGES—OLD AND NEW

By G. F. Wolfe

The author has had the opportunity to visit a large number of steel mills and unloading docks during the past two years. Through the coöperation of the various managers of the plants visited direct contacts were arranged with the operating personnel as well as inspections of the bridge equipment.

These contacts resulted in the raising of many questions both by those visited and the visitor; the most frequent question raised had to do with the useful life of bridges. While there is no direct answer to this question the data collected, which will be presented in this paper, does give information from which definite conclusions can be drawn.

The present state of unsurpassed activity in all plants is subjecting bridges to constant and unusually heavy service which is tending to delay routine maintenance. Capacities are being increased in some cases by adding

larger buckets. Much of the equipment is past the age where these are safe practices and careful and constant inspection should be part of the defense program.

A description of some of the newer types of bridges is given in considerable detail with special reference to the numerous safety features which are being incorporated in the modern bridge. The need for careful design is pointed out and reference is made to wind velocities recorded in the Great Lakes district during the past year which indicate that wind stresses should be treated as dynamic rather than static loads due to their sudden application and variable intensity.

Welding as a repair tool is discussed and certain requirements are outlined which are necessary to get proper results. The use of welding on structures without skilled supervision may well result in damage far beyond that of the part being repaired but properly handled it is a most useful and economical process. The rapid advance of welding in other lines of manufacture such as shipbuilding and crane construction with many advantages to both the builder and the user show the need for consideration of all welded bridges. The welding of ore bridges will insure lower maintenance and longer life at no increase in cost.

The use of low alloy steels will gradually affect the design of bridges but since welding will likewise enter the picture the selection of alloy steels must be limited to those suitable for welding under both shop and field conditions.

ELECTRIC WELDING MACHINES

By Chas. H. Jennings and Alfred B. White

Satisfactory welding can be produced with all of the different types of welding equipment—a-c., d-c., single-operator and multiple-operator sets.

The choice between single-operator and multiple-operator sets is dependent upon cost considerations, possible power factor conditions and work requirements. The multiple-operator set is particularly advantageous in cases where the ratio of welding time to overall time is low and the current required per operator is low (use of electrodes less than ¼ in. in diameter).

Weldability of the different types of machines is a controversial subject upon which machine designers and welding operators do not agree in all cases. It is important to point out, however, that the static volt-ampere curve of a welding machine cannot be used as the only guide of weldability. In metallic arc welding the dynamic characteristics of the machine must be taken into consideration.

The efficiency and maintenance costs of welding machines are closely associated with their design and construction. Low no-load losses are an important factor when the ratio of welding time to overall time is low. The percentage current drop obtained as the welding machine heats up from a cold start is also important, particularly if the machine is used near its full load rating or if the machine is located some distance from the operator.

A-c. machines of the transformer type have a higher electrical efficiency than rotating machines but they have poorer power factor unless power factor correction is used. An a-c. transformer welder with proper power factor correction is the most efficient type of single-operator welding set.

A-c. welding machines are somewhat restricted in their application because suitable electrodes are not available for the welding of non-ferrous metals such as aluminum, nickel and copper alloys. Suitable a-c. electrodes are available for nearly every welding application on ferrous materials and in such cases the welding efficiencies, costs and quality are equal to or slightly superior to those obtained with d-c. welding machines.

The major advantage of a-c. over d-c. welding is the greatly reduced amount of arc blow obtained. This condition is particularly advantageous on structures containing angles and corners and when large electrodes and heavy currents are used. The uniform distribution of energy obtained with a-c. between the electrode and work is of particular advantage when welding thin material. The use of reverse polarity d-c. often causes excessive heating of the work, which results in excessive distortion or the burning of holes through the work. The use of straight polarity often results in excessive heating of the electrode when enough current is used to obtain proper fusion of the work.

RECENT ADVANCES IN THE CONTROL OF MULTI-FUEL FIRED FURNACES

By John C. Vaaler

The use of more than one fuel on open hearth and soaking pit furnaces has stimulated the development of automatic control equipment for these applications. The earlier applications of control equipment to furnaces fired in this manner were usually accomplished by equipping the fans with dual inlets.

The use of multi-fuels not only aids in better fuel distribution throughout the steel plant, but also permits greater flexibility in operation to control flame character.

Among the systems which have been employed in the application of control equipment to multi-fuel fired furnaces is one which makes use of a summarizing device. In this arrangement, let us assume that two fuels are being burned, both under manual control, the first being coke oven gas and the second fuel oil. For each fuel a regulator would be provided to develop a pilot air flow proportional to each fuel flow. Each pilot flow would be directed into a summarizing device so that both flows would be summarized by a common orifice. With this arrangement, the common orifice measures the sum of the two pilot flows so that the differential developed by the orifice plate becomes the index of total fuel flow. It can be readily seen that this differential may then be used to actuate the combustion regulator to supply combustion air in proportion to the total amount of fuel being burned. Many variations of the summarizing principle have been employed in open hearth and soaking pit practice to secure the desired operation peculiar to any plant condition.

The equipment employed in any automatic control system applied to any furnace burning more than one

fuel requires some means of totalizing these fuels before the correct indication of combustion air requirements is secured. The pilot flow system previously mentioned has been in successful use for many years on these applications. A refinement of this arrangement is described in the following:

The heart of this refinement consists essentially of a summarizing gear. This device has the ability to add or subtract mechanically two mechanical movements so that the result is always the correct sum of the two. Its principle is similar to that which is employed in the differential gear of an automobile, in which the drive shaft will remain at a constant speed, while one rear wheel is turning faster than the other in making a turn.

A typical example of how the summarizing gear is applied to a furnace burning two fuels is described below.

An orifice plate located in the line of fuel number one develops a differential pressure proportional to the fuel flow and this differential is imposed on the primary system of a ratio regulator. The ratio regulator is arranged to control an operating cylinder in such a manner that its movement is proportional to the flow of fuel number one. This mechanical movement is directly connected to one-half of the summarizing gear.

A similar arrangement is used for fuel number two so that the regulator will develop a proportional mechanical movement in relation to the fuel flow. This mechanical movement in a similar way is connected to the second half of the summarizing gear.

When fuel number one is being used up to 100 per cent of its capacity and fuel number two also at 100 per cent of its capacity, the resultant mechanical movement transmitted to the summarizing gear will result in a 90 degree movement of the summarizing or totalizing shaft of this unit. Any smaller quantity of either fuel will be deducted from the total movement of the 90 degrees. Thus it can be seen that the resulting movement on the summarizing gear may be directed to a combustion regulator to supply total combustion air in relation to the two fuels being burned. This is accomplished by transmitting the mechanical motion from the summarizing gear to a ratio regulator, which in turn controls an operating cylinder operating the butterfly valve in the combustion air line.

The regulators employed in this arrangement are equipped with the usual accessories which provide for fuel air ratio setting.

Among the many possible arrangements available using the summarizing gear and ratio regulators are:

No. 1—Total air flow control with manual adjustment of two fuels.

No. 2—Total air flow control with automatic flow control of base fuel number one, and manual control of fuel number two.

No. 3—Total air flow control with individual automatic flow control of both fuels.

No. 4—Total heat input control providing for a varying supply of primary fuel and makeup automatically of secondary fuel.

No. 5—Total heat input control with constant ratio of fuels one and two, or provision for a variable setting of the ratio of the two fuels.

No. 6—Total heat input control with a varying supply of primary fuel and makeup of secondary fuel with temperature control superimposed.

No. 7—Total heat input control with varying supply of one fuel and automatic makeup of second fuel with provision to cut down supply of primary fuel if too much is available.

Diagrammatic sketches will be available to illustrate the basic layouts which cover all of the known applications for control of multi-fuel fired furnaces.

The use of the summarizing gear provides for simplification of control layouts wherever more than one fuel is being used.

WELDING IN COLD STRIP PROCESSES

By J. H. Cooper

This paper covers the various methods of resistance welding the ends of steel strip for processing in steel mills. It describes in design and operational detail the various types of apparatus for making varying grades of welds under different production conditions. Broadly, the subject is divided into two divisions, covering lap spot welding, and flash butt welding.

The spot welding equipment includes portable equipment for thin gauges and light production; semi-automatic equipment for wider strip in medium gauges and low production; and also heavy duty equipment for high production on wide strip and heavier gauges. The use of single point, multi-point and spot welding rolls is covered.

The flash butt welding covers automatic equipment from small welders welding $\frac{1}{8}$ in. x 4 in. strip up to the type of welder to weld $\frac{1}{8}$ in. x 80 in. strip.

Trimming of flash from the welds is included by necessity, as well as certain metallurgical and physical properties of the type of flash butt welds used for cold reduction.

FUEL APPLICATION TO METALLURGICAL FURNACES

By F. S. Bloom

This paper presents a discussion on the heating of steel in continuous billet heating furnaces and soaking pits. The subject matter to be covered consists of:

1. A discussion is presented, with curves, showing the heating absorption rate for steel billets and small ingots. These curves show actual tests made to determine surface temperature and inside center temperature of steel with constant furnace temperature.

2. Types of continuous billet heating furnaces are discussed to show:

a. The relation of furnace design and flame temperature on heating rates.

b. The progressive development of our heating furnace design with criticisms explaining the faults of our older furnaces and the reason why the newer designs are superior.

c. A method is presented for controlling the flow of gases in down-hill sloping hearth furnaces to prevent air infiltration and to allow furnace pressure to be controlled by stack damper.

3. Soaking pit heating and its relation to the heat

absorption rate of steel is discussed. Possible heating rates are presented with means for increasing production.

4. Preheated air and its problems.

5. The effect of fuel burner design and its relation to furnace design is discussed.

EFFECT OF RATE OF OPERATION IN THE COKE PLANT

By B. J. C. VAN DER HOEVEN

A brief study has been made of the effect of changes in operating rate on the coke plant. Changes in operating rate affect quality as well as quantity of products made. The cause for the change in nature of the product is discussed. Data are presented on yields of by-products at different operating rates, including tar, sulphate and benzol products. The surplus gas yield is especially affected by change in underfiring requirement.

Besides the effect on products changes in operating rate affect the plant itself, especially the ovens, and a brief survey is given of precautionary measures to be taken during rate changes. The practice of banking coke ovens is mentioned.

Data from operating plants on cost of production and credits versus operating rate are given. The nature of cost changes is analyzed in one example.

OIL FILTRATION AND RECLAMATION

By C. A. BAILEY

It is acknowledged that many theories of the technology of lubrication presume ideal conditions which may not exist, however, in the field. In recognition of that fact, the methods set forth in this paper are governed by economic and practical limitations. The maintenance of lubricating systems for industrial machinery is oftentimes independent of the selection of oils and only the problems involved in the maintenance of fluid lubricants will be considered. Oil circulating systems may be applied to many classes of machinery, including units involving from a few quarts to several thousand gallons. Regardless of the quantity of oil, the problems of cleanliness and chemical stability remain the same. It is generally agreed that oil does not wear out, but does change chemically and becomes contaminated with use. The greatest internal enemy of oil is oxidation, and the weakest or chemically least stable hydrocarbons will be the first to change in lubricating properties. It is this change in the oil, caused either by heat, chemical action within the lubricant or by ingress of contaminating materials, that constitutes the cause for oil filtration and reclamation.

The subject of oil filtration which is essentially a form of reclamation will be discussed in connection with the maintenance of small and large oil circulating systems. The discussion of small oil circulating systems will include test data for automotive and similar equipment, while that in connection with the large systems will refer to the maintenance of large volume centralized circulating systems.

The subject of oil reclamation which utilizes filtration methods will be discussed in connection with mechanical and chemical methods of treatment. Mechanical methods of reclamation will include the description of a waste oil recovery plant using a centrifuge to recover various types of lubricating oils. A system for the classification of lubricants is outlined as an aid to identification of salvaged lubricants. Chemical methods of reclamation with the use of neutralizing clays or activated earths will be discussed as being the most complete type of reclamation and that most nearly approaching refinery procedure.

OXY-ACETYLENE DEFENSE DEVELOPMENTS

By J. H. ZIMMERMAN

The status of the various oxy-acetylene steel mill processes is briefly reviewed with particular respect to the acceleration of development activities in line with the national defense program. The expansion of normal welding and cutting operations to cover increasing maintenance needs, the reclamation of obsolete or broken machinery and the salvaging of damaged equipment is discussed. The latest developments of special machines and processes to meet defense needs, notably, speed, precision, flexibility, economy and power-saving are also covered.

Compensation for an acute shortage of mill shears and saws has been provided for by the development of special oxy-acetylene cutting equipment for both hot and cold cut-off operations. Examples of mill applications in the cutting of billets, blooms, slabs and ingots are cited, and special consideration is given to multiple cutting operations for the production of shell forging slugs.

The demand for the direct production of accurately squared and beveled plates has led to the adoption of oxy-acetylene plate cutting equipment by a number of mills. New plate edge preparation machines designed to meet the needs of steel mills, as well as ship yards and fabricators, are described, and the requirements for edge preparation for welding are outlined.

Extensive research and development have made possible the application of oxy-acetylene cutting and treating to the higher alloy steels, notably, armor plate. Because of the shortage of heavy machine equipment much time has been saved through the gas cutting of armor plate to close tolerances. The air hardening characteristics of the steel have necessitated use of the flame softening process by means of which the flame cut surfaces are locally heat treated to restore the necessary toughness and machinability at the saving of much time and expense otherwise involved in the handling and furnace treating of the plate.

Reference is made to the fact that appreciable improvement in the ballistic resistance of homogeneous armor plate has been brought about by the application of the flame hardening process. It is also indicated that oxy-acetylene descaling may find wide use as a substitute for, or in conjunction with, other scale removing

processes. The author deals with these special process applications in detail.

The problem of steel conditioning by means of the oxy-acetylene blowpipe is reviewed and developments in equipment and procedures are described. The advantages of mechanized desurfacing of hot steel are enumerated, and the latest types of desurfacing machine installations are given consideration. Some mention is made of recent developments in the gas supply systems required for the large desurfacing machines.

The general conclusion is drawn to the effect that the part played by the oxy-acetylene processes in the national defense program is quite different from the simple proposition of maintenance as once was the case. It is further concluded that these processes now play an active and essential part in most phases of the production of steel from the blast furnace to the finished product, in the fabrication of the steel in practically every industry, and finally, in the demolition and scrapping of the steel after it has served its purpose in preparation for recharging and recycling.

TRANSMITTING TORQUE FROM ELECTRIC MOTORS

By A. M. MacCutcheon

The motor builder designs and builds motors capable of producing torque or rotative force. Machinery builders design and build machines requiring torque for their operation. Before the A.I.S.E. have been presented many papers on various types of driving motors. Also have been presented, many papers on the types of driven machines. Few, if any, papers have been presented on the means of transmitting torque from the motor to the machine. There are many problems to be considered and conditions to be met in the transmission of the motor torque to the driven machine, and it is hoped that this paper will record information which will be of assistance to the application engineer in the selection of the device to be used for the transmission of torque. It will not be possible to adequately cover the whole subject in a single paper, and it is further hoped that other papers will follow, building up a fund of information within the records of the A.I.S.E. relative to the various types of devices which are available for the transmission of torque.

In selecting the device which will connect the motor to the machine, the following factors should be considered and they are listed in what is believed to be their relative order of importance:

(a) Production
(b) Reliability
(c) Maintenance
(d) First cost
(e) Space occupied
(f) Convenience
(g) Simplicity
(h) Availability
(i) Losses present in the transmitting device

There are four basic requirements in transmitting torque. (1) There shall be a minimum loss in the torque transmitted. (2) The axis of rotation shall be, as nearly as is possible, coincident or parallel, since any departure therefrom results in undesired relative motion and consequent loss. (3) All parts shall have sufficient strength to avoid failure. (4) All contacts between surfaces having different peripheral speeds shall be adequately lubricated.

The second of these requirements is the most difficult to meet, and most of the failures in torque transmitting devices result from misalignment.

Torque transmitting devices may be conveniently divided into four classes:

Class 1—The transmitted torque is delivered at the same speed or rpm. at which it is received.

Class 2—The transmitted torque is delivered at a different speed or rpm. from that at which it is received but with a constant or unchanging speed ratio.

Class 3—The transmitted torque is delivered at a different speed or rpm. than that at which it is received, and within the transmitting device there is a provision to change the speed ratio at the will of the operator.

Class 4—The torque transmitted by the connecting device is subject to wide variations both in value of torque and the speed at which it is delivered due to frequent starting and stopping and the necessary acceleration of relatively large masses.

In each of these four classes, different problems are encountered requiring different types of torque transmitting equipment. These various types are discussed, and their advantages and disadvantages are set forth.

MODERN BLOOM AND BILLET HEATING FURNACES

By M. H. Mawhinney

The ideal billet or bloom heating furnace is that which will heat the steel with the maximum uniformity of temperature and with the minimum amount of surface damage.

The paper discusses the factors which affect this result, which include the furnace atmosphere, the control of temperature, the handling of the steel, and the type and design of the furnace.

The two principal effects of atmosphere on heated steel are to cause loss of carbon at the surface (decarburization) and loss of iron (scaling), which processes proceed simultaneously at varying rates depending upon the analysis of the atmosphere, which in turn depends upon the fuel-air ratio to the burners and upon the control of positive pressure within the furnace.

Other factors also affect both decarburization and scale, including temperature, the amount of subsequent reduction in area in rolling, time at temperature, and steel analysis.

The two general types of furnaces for the heating of billets and blooms are the batch type and the continuous furnace. Each has its specific applications and the only difficulty in choice occurs in the overlapping cases where either type will do the work reasonably well.

Batch type furnaces are more flexible in operation and apply mostly to specialty mills. The decarburization in batch furnaces is controllable, but only by careful attention to details of operation and design. The principle

details of importance include positive furnace pressure (which means forced draft for regenerative furnaces), tightness of construction, controlling equipment for fuel-air ratio and for temperature, adequate handling facilities, and attention to scheduling to insure minimum heating time. Attention to these details will pay dividends in existing furnaces as well as in those proposed for installation.

In estimating the size of such furnaces a rough average figure is 65 sq. ft. of furnace hearth area for each ton heated per hour, and the average fuel requirement is about 4.0 million Btu. per ton of steel heated. Handling equipment covers all types from simple manually operated peels to very heavy charging machines.

The control of steel quality in continuous furnaces involves attention to the method of discharging, stack draft control, zone control to prevent overheating during shut-down and slow-down periods, and temperature control.

Side discharge through a small side door is preferable to end discharging through the open end by gravity in all cases where decarburization is important, as is provision for zone control. Many new designs have been developed for zone control to meet more difficult specifications, including firing from the center, the two ends, and intermediate flues to the stack.

The size of continuous furnaces may be roughly estimated on the basis of 50 sq. ft. of furnace hearth area for each ton of steel heated per hour, and the average economy is 2.0 million Btu. in the fuel per ton of steel heated.

In conclusion, a study of furnaces for the heating of billets and blooms will disclose many possible improvements to improve production of steel of better quality and at less cost.

ROLLING AND BEARING PRESSURES IN STRIP MILLS

By M. D. Stone and J. I. Greenberger

This paper will bring together recent information on the pressures required to reduce strip in a hot strip mill at the various stages from the slabbing end to the finished strip end. It will particularly show how these pressures increase rapidly at the delivery end of the strip mill due to a combination of increased rate of compression and relatively high friction between the strip and the rolls. These pressures may be considerably higher than the specific pressures in the early stages of cold rolling, and will tend to indicate a basis for establishing a balance point between hot and cold rolling. In the cold rolling domain particular attention will be given to the pressure encountered in the finishing stands of tandem reduction mills as well as temper rolling stands, with special attention being paid to effects of front and back tension on rolling pressures.

The correct capacity of the motor-generator set for supplying power to the complete line will depend upon the summation of running light loads and working loads of all connected drives, but will not be materially affected by the operation at reduced speed. In some applications the working load decreases more rapidly than the speed of the material passing through the machine, but this does not normally affect the generator capacity since the generator must put out rated current at rated voltage and is therefore selected upon the basis of the total connected motor load with suitable allowance made for the load factor of each motor.

In presenting this paper, it is not the purpose of the author to change the established custom wherein the machinery manufacturer recommends the motor ratings for the mechanical equipment which he is furnishing; however, in most cases the purchaser's electrical engineer is responsible for the final selection of motor and motor-generator set rating, and it is hoped that the data contained in this paper will make the task simpler and quicker.

SCARFING HIGH CARBON AND ALLOY STEELS

By Geo. D. Winlack

Although torch deseaming or scarfing was first adopted by some of the leading steel companies twelve to fifteen years ago, it has been only the last few years that its great value to the industry has been fully recognized by practically all steel producers. Partially responsible for this recognition has been the constantly increasing demands for superior steel products produced at greater speeds and lower costs. This demand is exemplified by the high quality steel required by the automotive and aircraft industries and the railroads, in which all surface defects of blooms, slabs and billets must be removed at whatever stage of production they appear. To meet these increasingly stringent demands, a process must be employed that will do this work satisfactorily and with economy, yet not interfere with production schedules.

All steel producers fully recognize that the older methods of cleaning steel, hand chipping, machine chipping or swing grinding is not only exceedingly slow when considering the tempo of the present day production units, but also very costly. The storage and rehandling of large stocks of unfinished steel (this is a troublesome problem where one step in steel making lags behind the other) is a great obstacle in the high speed production program of the mills today.

With the newest steel cleaning method, torch deseaming or scarfing, it is possible to maintain a smooth production rate without difficulty and at the same time to conserve space, eliminate much handling, lower the production cost and produce a satisfactory product.

Use of the scarfing process for rapid removal of defects on or in alloy blooms, slabs or billets in the semi-finished form has increased very rapidly during the past few years. In fact, the use of scarfing for removal of defects has increased to such an extent that the tonnages of higher carbons and alloy steel now cleaned by this method compare favorably with that of the combined tonnages now cleaned by hand chipping, machine chipping and swing grinding. Large savings in time with large economies are being realized by plants using the oxy-acetylene cleaning process. It is in most cases from 8 to 15 times faster than mechanical chipping or hand chipping or swing grinding.

The value of the scarfing process becomes even more

apparent with the increase in the amount of surface cleaning required per ton of steel conditioned.

For a period after its introduction, the scarfing operation was only used as an auxiliary to hand chipping and on salvage or reclamation work for cleaning of badly cracked ingots, blooms, billets and slabs, which otherwise would be scrapped due to prohibitive cleaning costs. This is not so today. Development of deseaming techniques for the various grades of steel in their many sizes and sections, from ingots to 1½ in. square billets, along with many improvements in torches, tips and auxiliary starting equipment has advanced to a point where today scarfing is being done on practically all grades of steel which oxidize readily under an oxygen stream. Steels now being scarfed include all grades formerly chipped and a great number of grades formerly "swing ground." This includes practically every S.A.E. grade of steel with the exception of the corrosion and heat resisting steels. Also a great many special grades of alloy and tool steels not listed on the S.A.E. steel classification which are generally ground, can be and are being cleaned by the scarfing process.

The cost of scarfing per ton of steel will, of course, differ in the various plants depending upon several conditions such as type and quality of steel, size and section, amount of conditioning given, labor rates, inspection and handling conditions.

To quote an exact cost per ton for scarfing as compared to other cleaning methods would be impossible except in certain cases where the steels conditioned were identical in every respect. The final answer for the individual plants is the resultant economies obtained by the scarfing process over the cost of the prevalent method used.

MOTOR APPLICATIONS AND POWER REQUIREMENTS FOR STRIP PROCESSING LINES

By H. W. Poole

Considerable data has been accumulated and several papers have been written on the power consumption of hot and cold strip mills, but very little has been published and comparatively little data has been accumulated for strip processing lines.

It is not the purpose of this paper to approach the subject of power requirements for the various lines from the standpoint of energy consumption in kwh. per ton, but rather from the standpoint of the correct size, type and form of motor to be applied for doing specific jobs such as leveling and shearing tin plate, the effect of friction and other running light losses on motor selections, and the determination of suitable motor-generator set capacities. Although it is not feasible to present data on all of the types of complete processing lines in use today, the results obtained for various individual drives can be combined into different groups such as comprise many of the most common complete lines.

Data will be presented to show typical running light losses and actual horsepower requirements at various operating speeds for such drives as the following:

A. Roller levelers
B. Leveler-shears
C. Side trimmers
D. Slitters
E. Reels (winding and unwinding)
F. Pinch rolls

Inasmuch as most of the processing lines are now equipped with adjustable voltage control and the motors may operate for extended periods of time below rated speed where the self ventilation of the motor is reduced, it is advisable to select motors which will require less than full load current to develop the power required by the drive at low speeds. Typical examples of this type of application will be shown and a method of selecting the correct motor mill be indicated.

ELECTROLYTIC TINNING OF STEEL STRIP

By M. D. Stone

The purpose of this paper is to discuss in a somewhat general manner the economical, mechanical and electrochemical aspects of electrolytic tinning of steel strip. These questions have been, to a large extent, answered by the building and operating of a pilot plant which has produced electrolytically tinned strip suitable for dry packs at 500 ft. per min. By virtue of pertinent improvements in electrolytic plating technique, resulting in high current density plating, and the accompanying solution of mechanical problems involved in continuity of plating at these speeds, there was developed a plant which not only has resulted in a product which is much cheaper than conventional hot dipped tin by virtue of the reduced coating thickness, but also cheaper by virtue of reduced conversion costs as well. The development of such a plant was necessarily the result of joint efforts of the combined interests of companies specializing in plating technique and equipment, as well as strip handling and processing equipment coördinated in the plant of a steel producing company proper.

ORGANIZATION OF FUEL DEPARTMENT PERSONNEL AND PRACTICE

By T. J. McLoughlin

The steel industry today is faced with an unprecedented demand for tonnage to meet the needs of national defense and to adequately and simultaneously satisfy civilian requirements. This change to an industrial mobilization, geared to defense requirements has already produced shortages in the materials of production—some due to inadequacy of supply, some due to difficulties of transportation, and some due only to the accelerated rate of activity in those industries engaged in the manufacture of essential war material. Shortages in the types of fuel normally used in steel production is imminent and it is with this question of fuel economy and utilization with which we are concerned today.

The fuel requirement of a steel plant varies over extremely wide limits depending on whether it is fully

integrated, *i.e.*, contains all the manufacturing facilities from coke production to finished product, or is essentially a finishing unit, receiving its raw material as blooms, billets and slabs from steel producing units and converting these into finished product.

In the large steel plant of today the accurate control of combustion and the efficient production of utilities has become an entirely separate function, organized and staffed on the same basis as the public utility companies that furnish light, water, and in some cases heat to our homes and office buildings.

The changes of the past ten years in steel manufacturing methods, brought about by the necessity of producing a specialized product to meet each specific need of consuming industries, has emphasized the fact that economic and technologically correct fuel utilization and low cost utility production must be maintained if satisfactory and competitive overall costs of products are to be secured. The controlled temperature cycles of today are indispensable to the production of quality products that will give satisfactory results when processed in customers' plants.

This divisional type of organization within the steel producing plant, charged with the responsibility of maintaining technologically correct and efficient fuel utilization, and with low cost utility production, sells its products—steam, air, gas, water, electric power, etc., to consuming units at a fixed cost and operates under a standard cost system inwhich incurred costs are associated with definite responsibilities and not accumulated to particular products. Incurred costs are thus reflected against individual responsibility and distortion of management's judgment through arbitrary proration is avoided. Actual product costs, when necessary, can be obtained by adding plus and minus variations to standard product costs.

Such an organization has proven its effectiveness in efficient low cost production.

SEALING METHODS FOR OIL FILM ROLL NECK BEARINGS

Symposium by L. F. Coffin, T. R. Moxley, and D. N. Evans

During the past decade many improvements have been made in the design of equipment for rolling steel. One of the most outstanding of these has been the oil film roll neck bearing. Much credit is due those who have been responsible for this development. However, these bearings bring with them the problem of proper sealing to keep lubricating oil in, and foreign material out. Much detail work has been done on this subject by all manufacturers and maintenance men, but there is still much to be desired. Short papers by the three authors will discuss the various methods used to properly seal bearings of this type.

CONTROL OF WORLD RESOURCES OF STEEL-MAKING MATERIALS

By Charles Hart

The European war, which has brought about marked alterations in the geography of the European continent, has materially changed the control of raw material reserves, as well as the capacity for converting them into finished commodities. Iron has always served as the spearhead of Mars, and is even more essential to modern warfare. History, which is being repeated, shows a record, almost without surcease, of strife over control of these valuable reserves, and the present conflict was clearly indicated by their distribution.

This paper briefly summarizes the changes in control of the coal, iron ore, manganese and oil reserves, and of the steel producing plants in Europe. The necessity for industrial coöperation of the United States with England is emphasized.

REPORT OF FIELD TESTS ON IR DROP COMPENSATION

By G. E. Stoltz

Tin plate and sheet is now being produced on mills at high speed and to gauges within several ten-thousandths of an inch. Where tandem mills are used this performance is obtained by careful adjustment of the draft made in individual stands. In order not to disturb the reductions made, it is necessary for the driving motors to maintain the speed relationship for which they are set regardless of variation in load conditions. The reason for this is that on tandem mills the volume of metal being delivered from each individual stand in a given time must be the same. Otherwise the tension between stands would increase or loops would be accumulated.

The final gauge of the strip being rolled is a result of roll pressure on the individual stands and tension between stands. If the roll pressure remains the same and the speed of the driving motors continues in the same relationship to each other, the tendency will be to obtain uniform gauge.

This speed regulation can be obtained on properly designed direct current motors when they are operating at full load voltage, but external means is used to maintain regulation at reduced voltages. The most effective means of obtaining this is the use of demagnetization and *IR* drop compensation. With this equipment any degree of speed regulation can be obtained at full voltage or at reduced generator voltage.

This paper will present test data on tandem mills operated by electrical equipment with and without *IR* drop compensation.

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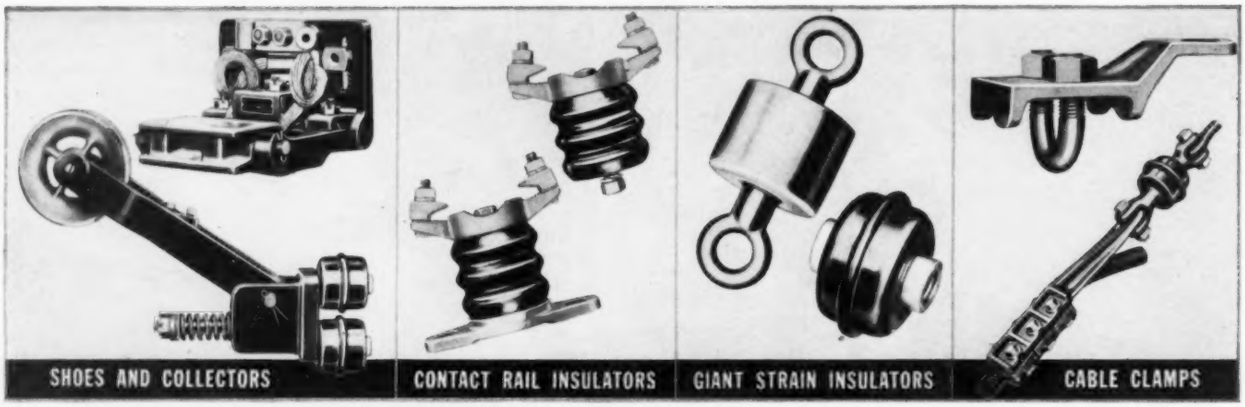

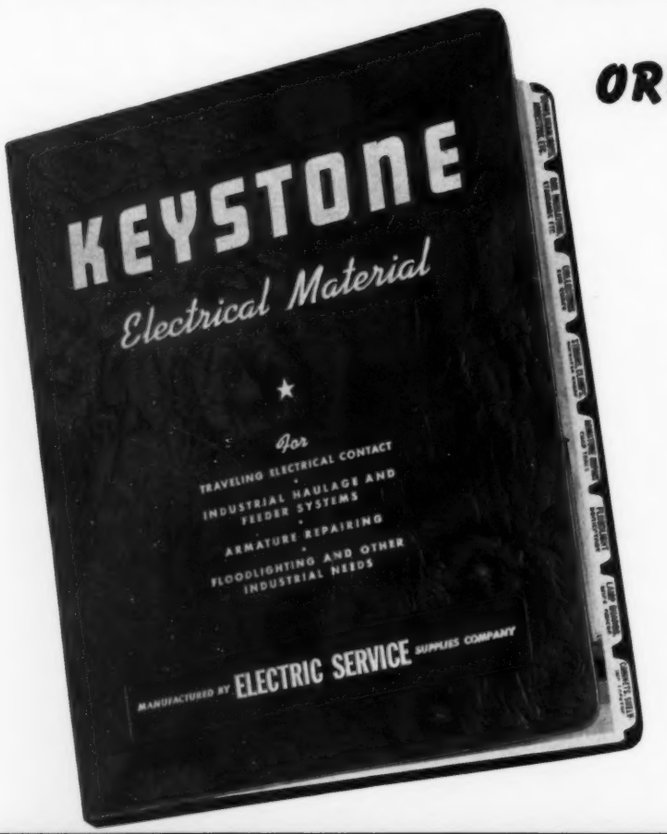

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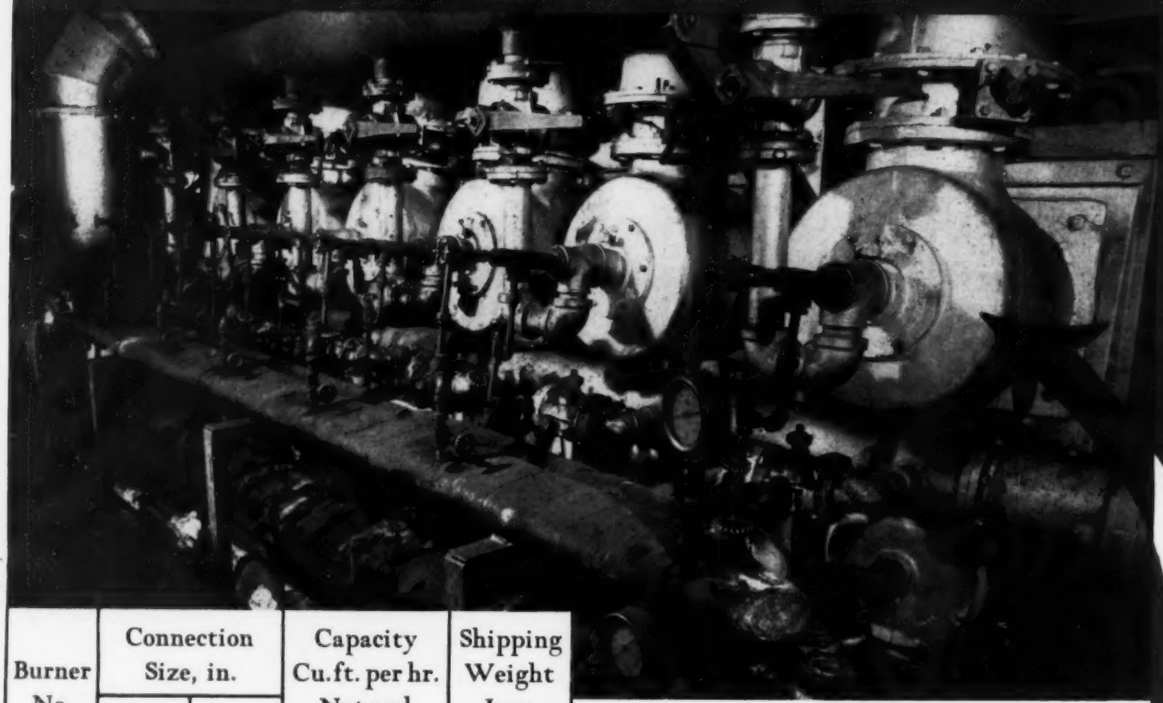
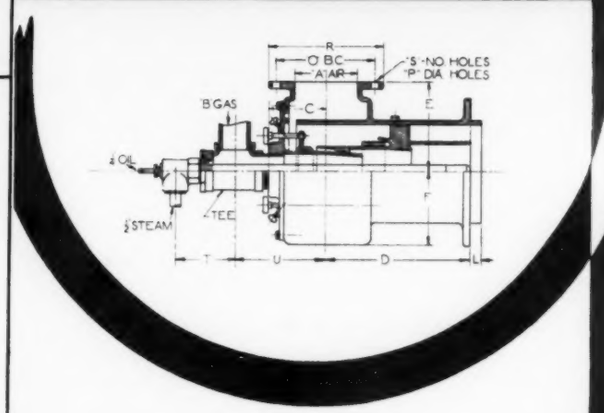


Burner No.	Connection Size, in.		Capacity Cu.ft. per hr. Natural Gas	Shipping Weight Less Block
	Air A	Gas B		
2	2	1	500	38
3	3	1¼	1,000	65
4	4	2	2,000	130
6	6	2½	3,000	210
6	6	2½	4,000	220
8	8	3	6,000	443
10	10	3 or 4	9,000	475
12	12	3 or 4	12,000	483
12H	12	3	12,000	735
16H	16	4	16,000	944
18H	18	6 Flg.	30,000	1,750
18C	18	8 Flg.	30,000	1,750



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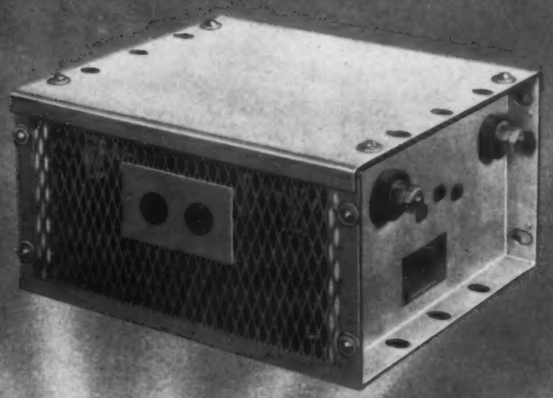

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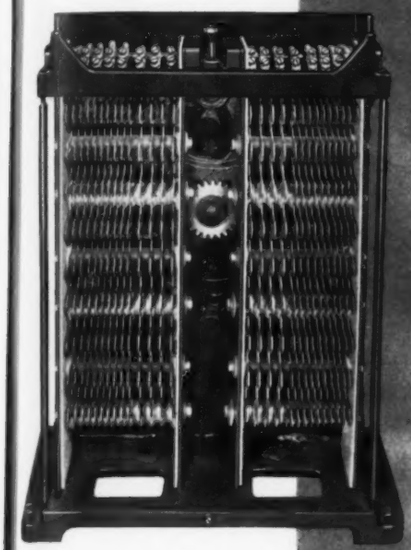

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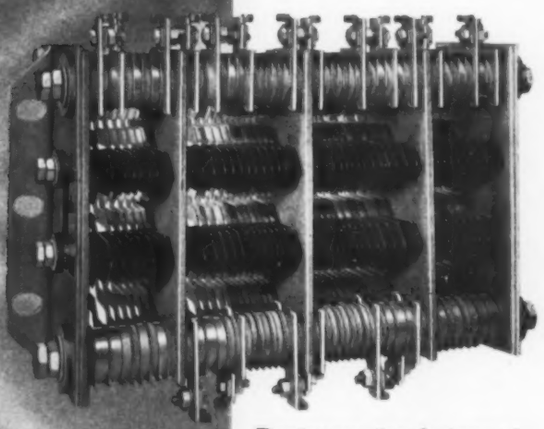
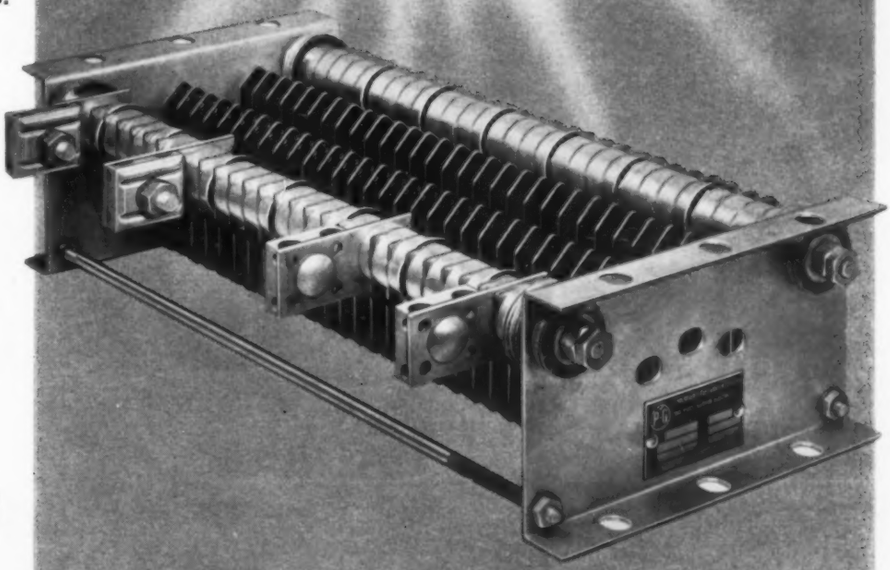


Resistors for Internal Mounting in Small Face Plate Controllers.

Standard units for 2 to 25 H. P. Motors.



SEE THESE *Steel Grid* **RESISTORS** *at* **BOOTH NO. 83** *Iron and Steel Exposition*

STANDARD UNIT BANK

Used for all types of resistor applications.

"The Resistor you can Install and Forget"

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI, OHIO

DON'T MISS SPACES 98 and 99

AT THE IRON AND STEEL SHOW

See how

DUST, SOOT, SMOKE *Vanish*

WHEN THE AMERICAN

ELECTRO-MATIC

SELF CLEANING ELECTRIC PRECIPITATOR

is on the job

To those unable to attend the show we will be glad to send a copy of the new Electro-Matic Bulletin which explains in detail the collection of dust, soot, and smoke by electric precipitation. Address Department 305.

AMERICAN AIR FILTER CO. INC.

INCORPORATED

LOUISVILLE, KENTUCKY

A. I. S. E.

Welcome

to BOOTH No. 100

where

TRUMBULL

representatives

will be on deck to greet

our many friends

in the Industry

and to discuss Trumbull's

important contributions

to electrical efficiency

under present day

plant conditions.

"RAGGED ARMIES"

(of electrical control equipment)

CAN'T WIN INDUSTRY'S EXPANSION BATTLES

But, look at these pictures of NEW Trumbull Motor Control Centers . . . standardized units that put together just like a kid's building blocks.

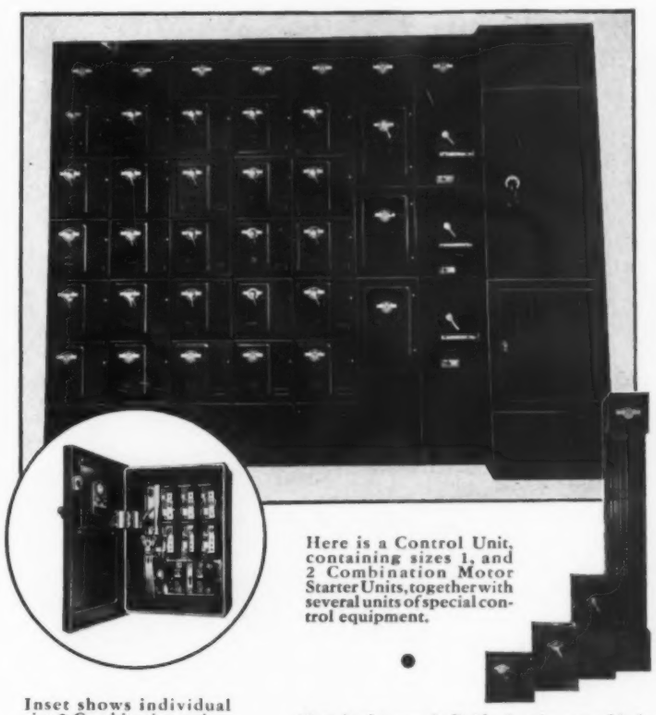
TIME-SAVINGS in ordering . . . installation . . . wiring and hook-up to machines.

SPACE SAVINGS, with trim, efficient, centralized control units, instead of a "ragged army" of unrelated equipment. Push-buttons, of course, for remote control from operating stations . . . perfect set-up for multi-motor machines.

FLEXIBILITY when you have to expand (or contract), relocate or change-over. Control units can be re-grouped in sections or sections re-grouped in the plant.

And think of the EASE of ordering these completely standardized control units for rapid installation.

Equipment like this will help solve your defense speed-up problems . . . and quickly open up electrical bottlenecks.



Here is a Control Unit, containing sizes 1, and 2 Combination Motor Starter Units, together with several units of special control equipment.

Inset shows individual size 2 Combination unit.

Here is the way individual units assemble in the section trough . . . 5 size 1; 3 size 2 or 2 size 3 motor starter combinations or all sizes assorted.

TRUMBULL

ESTABLISHED 1888

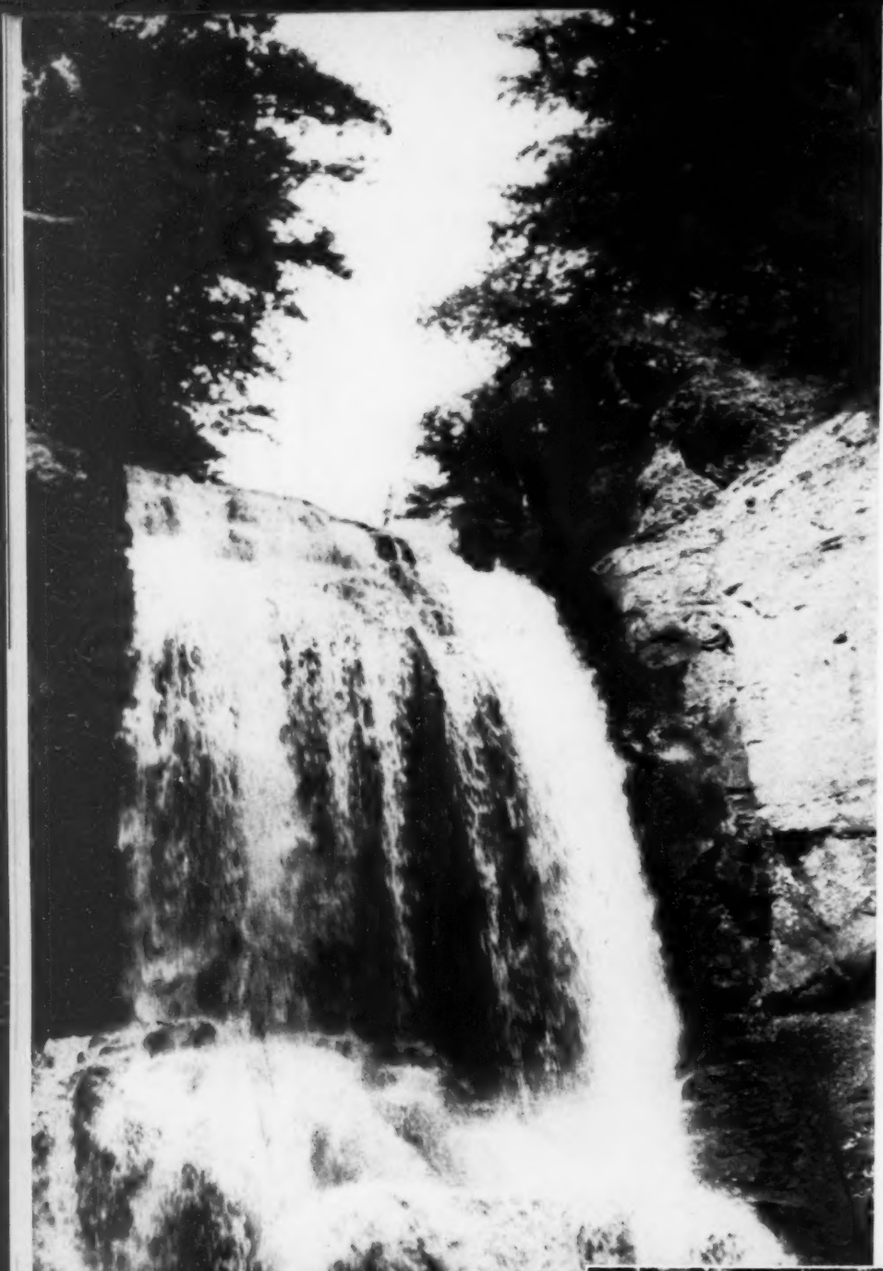
THE TRUMBULL ELEC. MFG. CO.

PLAINVILLE CONN. U.S.A.

A GENERAL ELECTRIC ORGANIZATION

KEEP *Alert* ELECTRICALLY use your TRUMBULLAIDS

NEW YORK - PHILADELPHIA - BOSTON - CHICAGO - DETROIT - LUDLOW, KY. - ATLANTA - NASHVILLE - LOS ANGELES - SAN FRANCISCO - SEATTLE



Water..often beautiful . . always practical as a lubricant for Ryertex Bearings

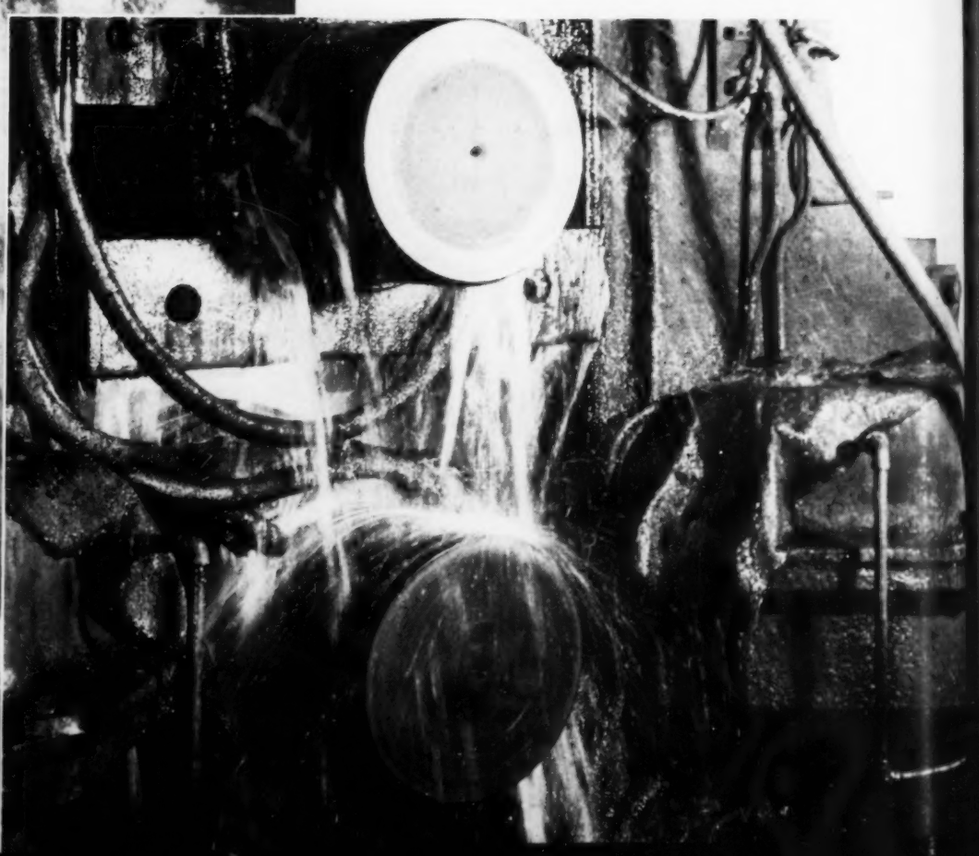
● When water-lubricated Ryertex Bearings guard roll necks and other vital spots in your mill, you can depend on:

1. Substantial reductions in grease and oil lubrication costs.
2. Reduced power consumption.
3. Increased tonnage.
4. Lower maintenance costs.
5. Cleaner mill.
6. Longer bearing life.

Whatever your bearing problems—whether they concern roll necks, spindle carriers or roller twist guides—call in a Ryertex engineer. He is familiar with many applications in many different types of mills and will be glad to work with you on your particular problem.

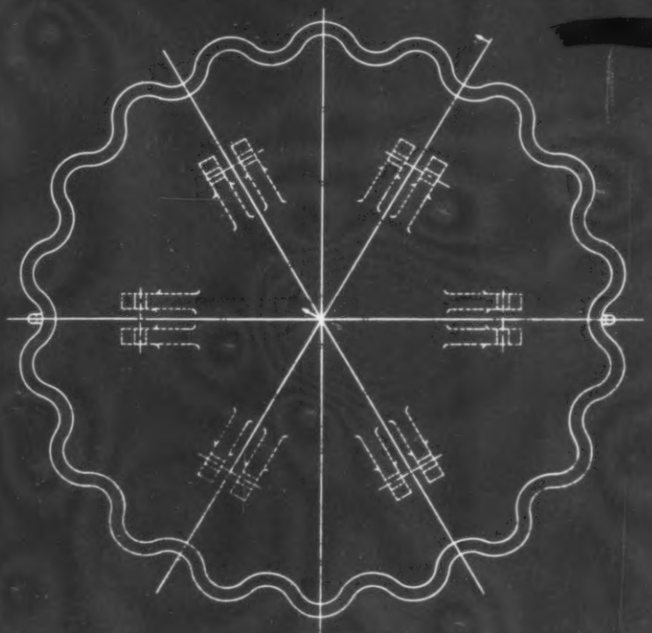
Joseph T. Ryerson & Son, Inc., Chicago, Milwaukee, St. Louis, Cincinnati, Detroit, Cleveland, Buffalo, Boston, Philadelphia, Jersey City.

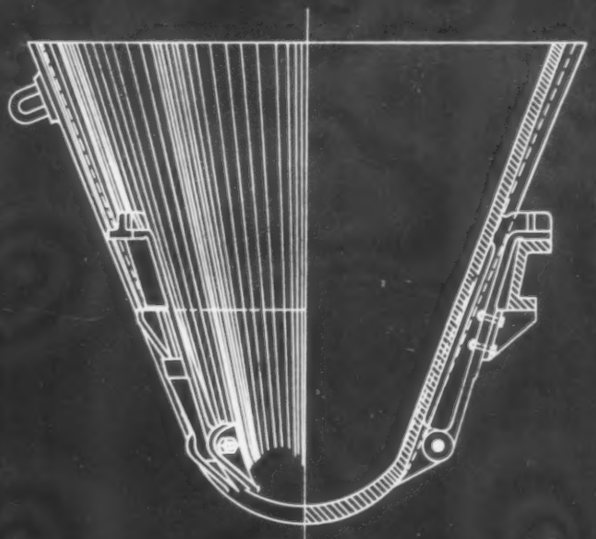
RYERTEX BEARINGS



easier dumping and skulling
greater strength and flexibility
longer pot life

these are the advantages you get





WITH THE IMPROVED JOHNSTON CORRUGATED CINDER POTS

These outstanding advantages you get with the IMPROVED JOHNSTON CINDER POTS are made possible by the design, which has, as one of its features, greater wall area because of the corrugations for rapid dispersion of heat. Then, because all castings expand with heat and contract during cooling, the corrugations permit unrestricted expansion and contraction, and provide greater resistance to distortion and creep in the critical heat zone, which is in the middle third section of the pot.

Many of the largest steel plants in the country have standardized on Johnston Corrugated Cinder Pots, and during the past five years 75 per cent of all pots purchased have been Johnston Corrugated Cinder Pots.

Put these money-saving cinder pots to work in your open hearth and blast furnace departments—they will operate longer, more efficiently, and give you lower cost per ton of product. Wire, telephone or write for one of our engineers to discuss with you your slag handling problem. No cost or obligation.

Advantages of Johnston Corrugated Cinder Pots: Longer life . . . Quicker cooling of slag . . . Stronger, safer pots . . . Permits unrestricted expansion and contraction . . . Pot walls relieved of all tension—walls supported in compression . . . Pots supported from coolest point . . . Uniform support of pot, regardless of misalignment of bail ring.

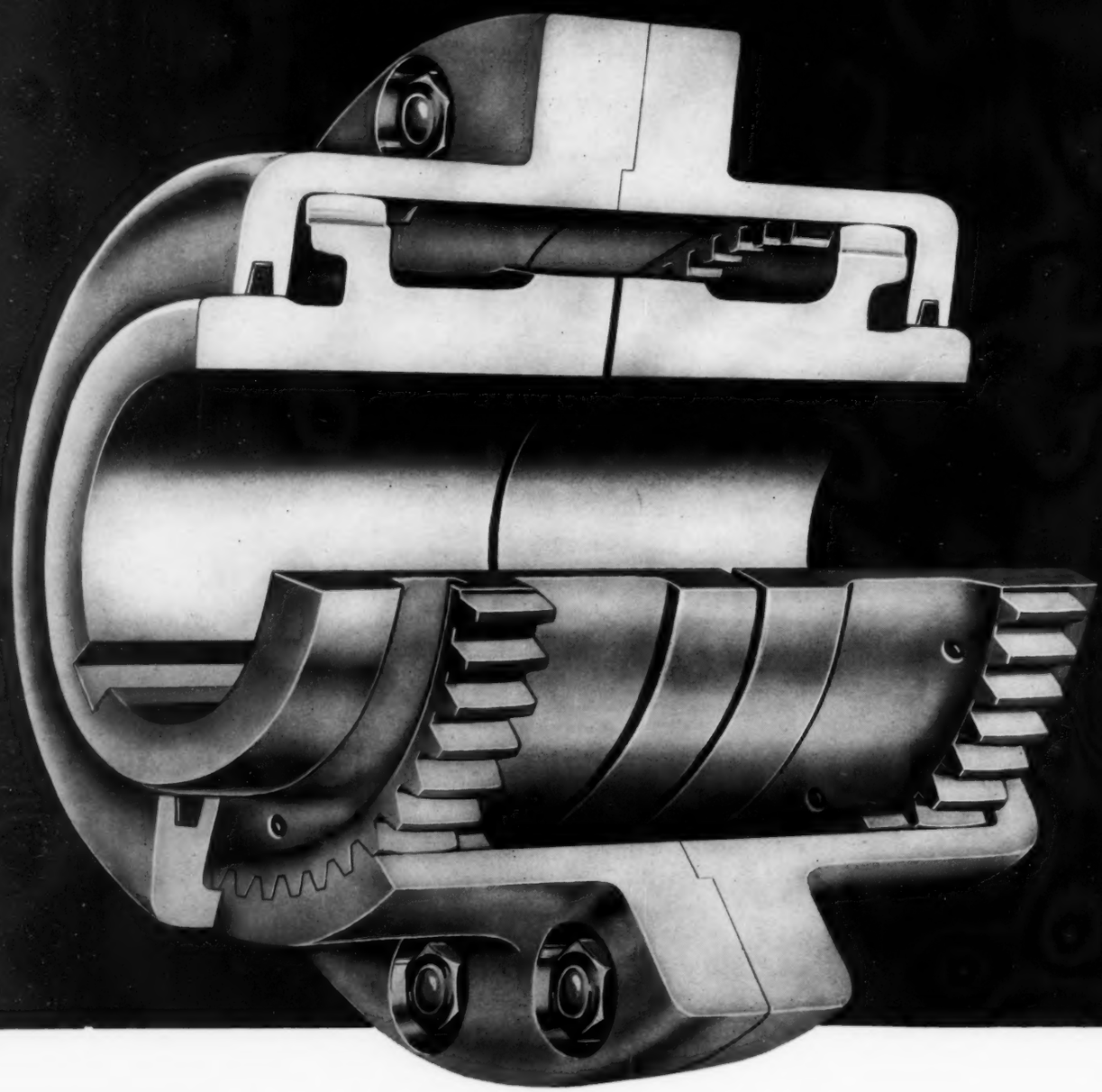
MACKINTOSH-HEMPHILL COMPANY · Pittsburgh and Midland, Pa.

Mackintosh-Hemphill Company is the exclusive licensee for the manufacture and sale of Johnston Patented Corrugated Pots and Supports.

Other Mackintosh-Hemphill Company Products:

"Techni" Process Rolls . . . Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers Pinions . . . Special Equipment . . . Iron-Steel Castings . . . And the New Abramson Straighteners for solid rounds, pipe, tubing—for sizing and polishing.

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

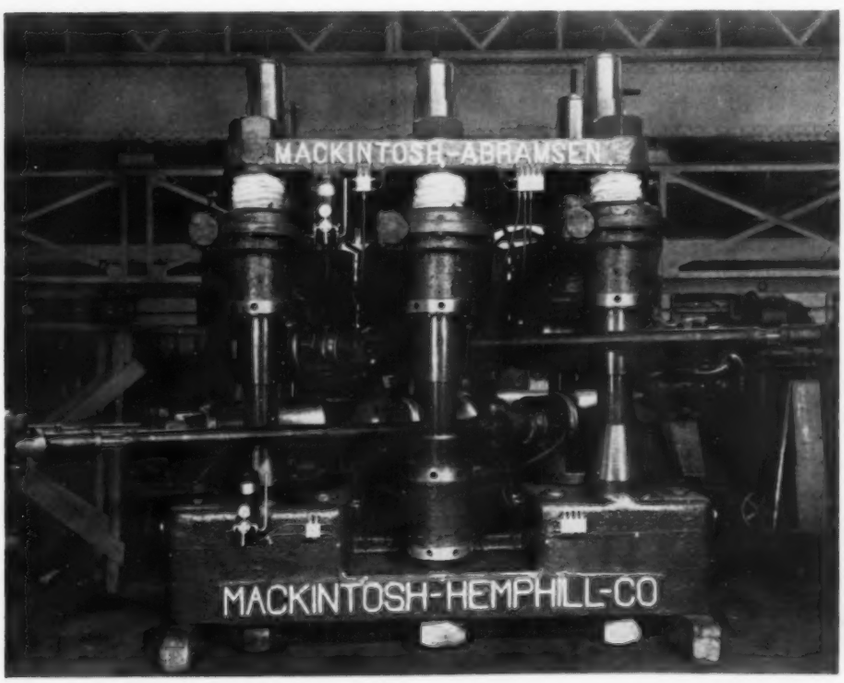
LARGE STRAIGHTENER FOR CANADIAN PLANT

▲ A huge 92,000 lb. alloy bar straightener, designed to break precision production records for Canadian defense, has just been produced by Mackintosh-Hemphill Company, Pittsburgh, Pennsylvania, for the Page Hersey Company of Wellington, Ontario, according to W. M. McConnell, chief engineer for Mackintosh-Hemphill.

"This is one of the largest straighteners ever produced and the first we have ever made that will easily handle 6 in. solid alloy steel rounds," Mr. McConnell asserted. "It is also the largest bar straightener ever produced without guides, to the best of our knowledge."

"The elimination of guides allows greater production speeds, and this straightener will run from 80 to 320 ft. per min.," Mr. McConnell concontinued. "The machine has a number of other features which make it unusual. It will completely straighten a heavy bar from end to end and remove all end-bends or camber. For greater ease of operation, all adjustments are on one side of the machine and all hand operated parts are spring balanced. All operating parts have been sealed against scale or dirt."

Mr. McConnell said that this machine, which has already been shipped to Canada, is equipped throughout with Timken bearings, both roll neck and drive, and is powered with two 75 hp. motors, low power for a machine of this size, but made possible by high precision operation.



This heavy unit will completely straighten bars up to 6 in. diameter, removing end-bends and camber.

BLAST CONDITIONING INCREASES IN FAVOR

▲ Steel companies faced with increasing production during the present emergency, realize this can be accomplished in several ways. The quickest solution to the problem of stepping up production on existing furnaces, however, is to install dry blast systems. This method of improved production is not new. York installations were made in 1904 at Isabella furnaces, Warwick furnaces and others, and the result secured from that equipment can now be duplicated with more modern designs incorporating new methods of dehumidification. While not new, the art has been developed to a more practical stage with reduced space requirements.

The advantage of dry blast makes it desirable to give full consideration to its application.

Increased production is obtained by changing the burden ratio, making it possible to secure more pig iron with the same furnace.

A change in the burden ratio also means that a reduction in the quantity of coke makes a considerable saving, which is dependent upon the amount of moisture introduced into the furnace. This variable factor must be corrected by the operators who must guess in advance what atmospheric conditions will be.

Uniformity is obtained by leveling

out the moisture conditions in the furnace to a constant quantity, thus eliminating one of the wide variables in blast furnace operation.

Steam consumption of the blowing engines is reduced due to the changes in volume of air handled. This steam which is available may in some cases be sufficient to operate the water cooling system.

A dry blast system on the suction side reduces the maintenance and upkeep on the blowing engine, inasmuch as clean air without the contamination of dust and cinders contributes to the longer life of the valve mechanism.

Systems can be designed according to the requirements and are grouped basically into two types.

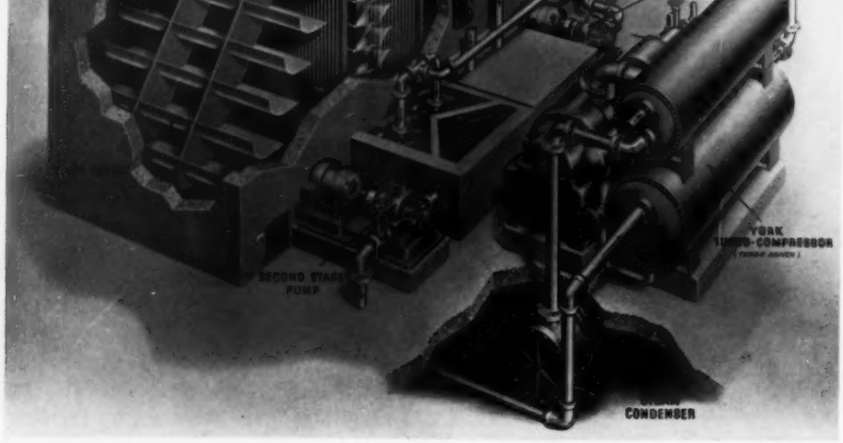
The illustration shows the most commonly employed type of system for reduction of moisture content to three grains per cu. ft. This application incorporates the use of a water cooling system, cooling the water which is sprayed in the second stage of the dehumidifier. A recirculating pump then takes water from the second stage and recirculates it through sprays in the first stage. It is possible to maintain a uniform moisture content at all times under automatic control accomplishing all the advantages previously mentioned.

For requirements of lower moisture content air, down to as low as one grain, it is possible to design equipment using water within the range of temperature commercially practical. In this case advantage is taken of some external source of water which may be available at 85 degrees to 100 degrees F. temperature to do the initial cooling and dehumidifying. Remaining stages with the refrigerated water make possible a constant moisture content leaving. This design may also incorporate heat recovery apparatus so as to reduce refrigerating requirements where justified.

This type installation increases the air conditioning requirements to the system, inasmuch as the heat of compression of the blowing engine must be taken into account. It is not possible to reduce the steam consumption of the blowing engine when placed on the pressure side. Thus it is necessary to design a system, for every application, taking into account the temperature of available water, space requirements, location of equipment and source of power.

Dry blast is important, consequently, to every blast furnace operator, and experience so far secured indicates that the advantages are real and conclusive.

This dehumidifying system employs refrigerated water for spraying in the second section of the unit.



The most recent installation to be placed in operation by York is one for Republic Steel Corporation, Birmingham, Alabama.

NEW COUPLING FOR MILL EQUIPMENT

▲ The Falk Corporation adds a new coupling to its line of steelflex couplings with the type P—piloted coupling for floating shaft requirements.

The Falk piloted coupling is especially adaptable for use in paper mills, on steel mill auxiliary drives, on main rolling mill drives, horizontal and vertical pumps and exhaust draft fans.

This new coupling combines the resiliency and shock cushioning section of the Falk general duty steelflex coupling with a low angle universal joint action, thus eliminating the necessity for an outboard bearing on extended shafts or auxiliary bearings on intermediate shafts. This feature makes possible a large saving in installation cost, space and foundation requirements for auxiliary bearings. The piloted couplings also allow greater flexibility in locating the driving and driven units.

The Falk piloted coupling is constructed entirely of steel. It consists of two hubs, one of which carries an integral flange to which the cover is secured, a special tempered steel member forming a complete cylindrical gridmember and flanged steel cover secured to the hub flange with capscrews.

TRANSFORMER COMPANY OBTAINS NEW OFFICES

▲ The offices of Pennsylvania Transformer Company are now located in their beautiful 35 room mansion at 808 Ridge Avenue, N. S., Pittsburgh, Pennsylvania. Their four story, tapestry brick building was formerly the home of an official of a large steel company. It is strategically located—only five minutes by car from downtown Pittsburgh, and eight minutes by car from the Pennsylvania Transformer factory at 1701 Island Avenue, N. S., Pittsburgh, Pennsylvania.

Pennsylvania Transformer Company has long felt the need for more spacious office quarters. This new building is well situated and suited to the company needs. The executive, sales, accounting, engineering and drafting departments are located in it.

Close contact between factory and office will not be lost. A plant engineer and draftsman are stationed at the plant, eight direct telephone lines connect the two buildings—company cars travel back and forth continuously all day long.

DEHYDRATION FOR BLAST CONDITIONING

▲ Blaw-Knox Company has developed a dehydration plant of the absorption type for the conditioning of blast furnace air. The plant is fully automatic and requires only the normal supervision of motors and control equipment. Under the usual conditions found at most plants blast air can be supplied to the blast furnace at any desired moisture content down to 1½ grains per cu. ft. Under certain conditions, even this 1½ grain loading can be decreased.

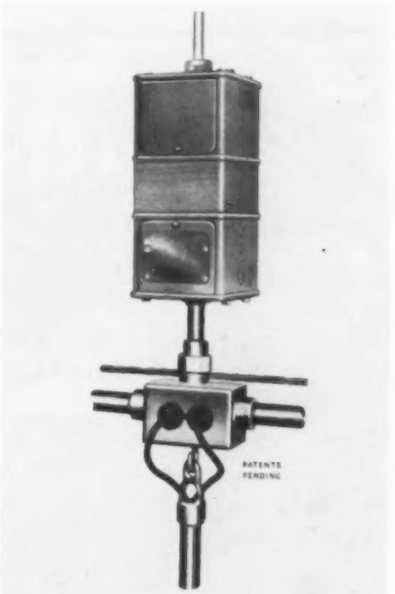
Experience with the first installation, which has been operating for a year, demonstrates that the equipment has great flexibility and that the method employed for dehydration lends itself to low operating costs. There is evidence that the theoretically figured benefits in increased tonnage, reduced coke consumption and improved quality in the iron as a result of using dry blast will be realized to an appreciable degree. Thus, apart from the timely importance of assuring maximum tonnage in iron production, the results are gratifying enough to promise a good return on the investment.

The Blaw-Knox plant is designed to remove both water vapor and dirt from the blast air, controlling the air going to the blowing engines at a predetermined vapor content and temperature. The vapor is removed by absorption through contact with a hygroscopic salt solution. Heating and cooling coils ahead of the dehumidifier maintain the outlet air at the predetermined temperature, depending on the solution concentration and the cooling water available. The water vapor picked up by the solution is then, in a constantly operating closed cycle, driven off by heat supplied in steam coils so that the solution is maintained at the desired specific gravity corresponding to the set constant grain loading desired. The dirt is removed from the air by means of a continuous oil bath filter.

A number of variations may be secured in the operation of this equipment, depending on the temperature of the outlet air desired and the atmospheric conditions under which the unit operates. During periods of continued low atmospheric temperatures, the concentration of the salt solution may be reduced and the entire apparatus operated at some new setting of outlet temperatures with a resultant saving. If the humidity of the atmosphere is less than the maximum allowed for in the design, then the inlet temperature can be higher without affecting the control point, and the reverse is also true.

FIXTURE HANGER FOR COMBINATION LIGHTING

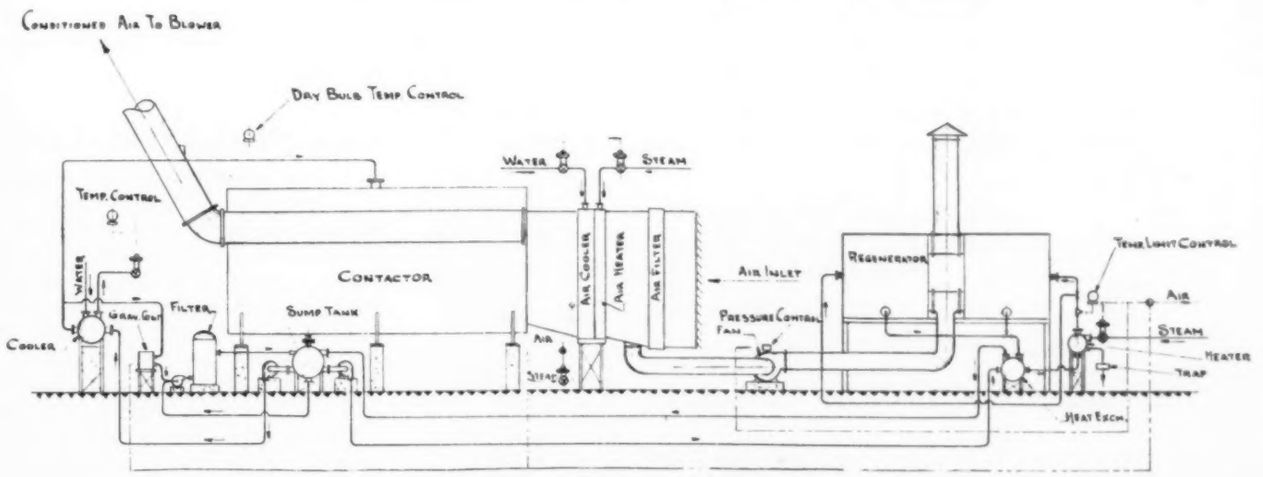
▲ The Pyle-National Company, 1334 North Kostner Avenue, Chicago, Illinois, announces a fixture hanger Pylet especially designed for installation of the combination mercury vapor and incandescent lamp fixtures being widely used in industrial plant lighting.



Installation of this type of lighting is simplified, and maintenance made more convenient.

The "U" Series fixture hanger Pylets provide for permanent mount-

Diagram showing general arrangement of absorption type plant for blast conditioning.



ing of the transformer required for the mercury vapor lamp above the messenger or span wire. The weight of the transformer is carried by the support rod attached to the ceiling structure of the building. Shorter and lighter weight fixture stem assemblies can be used with "U" Series Pylets, with consequent lowering of the messenger wire height. With this method of installation the lighting fixtures only are below the messenger or support wire and may be removed independently for maintenance attention. No unnecessary handling of the transformer is required.

The union hub of the Type "U" Pylet is slotted to receive the messenger wire and a steel barrier is provided within the hub through which the messenger wire can slide without danger of abrasion to wiring. Space is provided for two pairs of No. 10 wire, each pair passing through on opposite sides of the messenger wire barrier. The union nut will not loosen when installed, as pressure on the messenger wire has a locking effect.

The Pylet body will take a single or two gang receptacle providing for attachment plug connections to the mercury vapor and incandescent lamp circuits. A hook is provided at the bottom of the Pylet body to fit the Pyle-National Type A double outlet fixture loop for two portable cords. Both hook and fixture are designed so that the fixture pendant must be raised to an angle of approximately 45 degrees before the fixture can be detached from the hook. This avoids the hazard of disengagement through excessive swinging of the fixture.

The "U" Series fixture hanger Pylets are available in two sizes, with ¾ or 1 in. conduit hubs.

Now you match the combustion control to your furnace

THE Askania "Summarizing Gear" has been developed as a further refinement in the application of combustion control to multi-fuel fired furnaces. It permits you to:

—Compensate for air infiltration
—Use any flow impulse
—Adjust for various atmospheres

Here is a simple, can't-go-wrong device—the answer to a combustion control problem where more than one fuel is burned.

See it at BOOTHS 64 and 65
Iron & Steel Engineer's Exposition, Cleveland
Sept. 23-24-25

If you can't be there to see this typical Askania advancement, write for interesting details.

ASKANIA REGULATOR CO., 1603 S. Michigan Ave., Chicago

ASKANIA CONTROL
"IF IT CAN BE MEASURED — WE CAN CONTROL IT"

NEW DESIGN GIVES LOW VOLTAGE DROP

▲ The Trumbull Electric Manufacturing Company of Plainville, Connecticut, has recently placed on the market a newly designed L.V.D. (low voltage drop) Buss-Wa, which has specific advantages in design and performance that speed production, conserve power, save time and cost.

Low voltage drop is the result of an entirely new principle in the design and spacing of conductors with every detail of construction and insulation accurately balanced to reduce reactance value of the circuit.

Mechanical strength and bracing of conductors is amply heavy to prevent failure under mechanical stress due to short circuit conditions which may occur with the general use of low impedance and high capacity transformers.

OHIO WORKS INSTALLS WORLD FAIR PUMP

▲ Built new and installed in 1939 at the Electric Utilities Exhibit at the World's Fair in New York, a 24 in. x 20 in. Type A-25 Dayton-Dowd centrifugal pump fitted with a 200 hp. Westinghouse slip ring motor and automatic control was recently sold and shipped to the Carnegie-Illinois Steel Corporation for use at their Ohio Works at Youngstown, Ohio.

The pump was sold by John D. Crawbuck Company, Empire Build-

ing, Pittsburgh, Pennsylvania, who have long specialized in the sale of used and rebuilt electrical and mechanical power equipment.

Capable of handling 15,000 gal. per min. against 45 ft. total dynamic head at 69 rpm., the pump was built with carbon steel shaft, semi-steel nickel impeller and otherwise bronze fitted. Included with the outfit was a size MD-57.3 Nash Hytor priming pump driven by 1½ hp. Westinghouse motor.

Many who saw the Fair will remember the cascading waters over the facade and glass canopy entrance to the Electrical Utilities Exhibit, all made possible by this pump unit. As everyone knows this pump saw service only six months in 1939 and six months in 1940, but has now joined active service in the defense program.

NEW TYPE PICKLER OFFERS ECONOMIES

▲ The large continuous strip picklers used by the steel industry today are the result of long years of research and development. They are expensive pieces of equipment, but if they can be kept busy, are capable of handling large tonnages of steel in a very efficient manner at a low cost per ton. In view of their installed cost they are more or less limited to the larger companies where there exists a sufficient demand.

These conditions do not prevail in the case of many small cold rolling companies operating today using purchased hot rolled strip, who for various reasons are either unable to purchase their requirements in pickled strip or find that, due to storage conditions, it is inadvisable to do so. In the majority of cases we find such companies resorting to tub picklers, which require comparatively simple equipment but are expensive to operate due to the great care required in loosening and properly separating the layers of the coil in order that the acid may pass through freely and come into contact with the entire strip area.

In an effort to find a solution to this problem, United Engineering and Foundry Company in 1935 developed a coil type pickler of which a number have been installed and are working satisfactorily. The primary virtues of this pickler are low first cost and greatly diminished space requirements, in addition to desirable operating economy—where reasonable large tonnages are involved. This pickler has its limitations, too, primarily for large coils of light gauge material.

Along the lines of providing a lower cost, smaller production unit, United undertook to ascertain the possibilities of expanding the application of a simple type of pickler known and operated in New England for some time. This pickler was originally developed by the Stanley Works of the American Tube and Stamping Company, incorporating features covered by a patent owned by that company, and under which United has an exclusive license. The original installations were modest in character, operating on narrow width, but on multiple strands, in some cases.

The operation of these units was carefully studied and the possibility for wider strip appreciated. Accord-

CROUSE-HINDS
1
Condulets
Superior conduit fittings and enclosures for every electrical wiring requirement. Over 15,000 types and sizes are listed in the Condulet catalog.
2
Floodlights and Searchlights
For protective lighting and plant operation at night. Both heavy duty and light duty floodlights.
A Nationwide Distribution Through Electrical Wholesalers
3
Engineering and Manufacturing Service
Many conduit fittings of a technical nature now being used by the trade were designed and engineered by Crouse-Hinds.
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Resident Salesmen: Albany — Atlanta — Baltimore — Buffalo — Charlotte — Denver — Louisville — New Orleans
CROUSE-HINDS COMPANY OF CANADA, LTD.
Main Office and Plant: TORONTO, ONT.

ingly, a line of equipment was designed which led to the first commercial installation at the Detroit Steel Company—now in operation. This is a double strand unit handling two strips simultaneously up to a maximum of 22½ in. in width for each strip, and having a range in thickness from .060 to .250 in. It is arranged for a nominal speed of 85 ft. per min. and should comfortably handle from 10,000 to 12,000 tons of average gauges and widths per month.

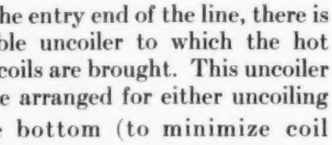
At the entry end of the line, there is a double uncoiler to which the hot rolled coils are brought. This uncoiler may be arranged for either uncoiling off the bottom (to minimize coil breaks) or off the top, in which the operation is considerably simplified. The front end of the coil is inserted between a pair of pinch rolls, air operated, which leads the strip into the leveler. The leveler is multi-roll to assure strip flatness, and aid in scale breaking, and has the last roll adjusted so that the strip has a slight tendency to bow upward.

The strip is led between a pair of steel brushes rotating in the same direction as the strip travel. These brushes are operated wet and are employed to brush off any particles of scale which have been mechanically broken by passage through the leveler. From the leveler the strip is picked up by a set of guides which confine it both vertically and horizontally through a slot leading into the first acid tank.

There are two acid tanks in the line, the first of which is 45 ft. long and the second, 90 ft. long. The tanks themselves are shallow, slightly over 12 in. in depth of proper acid resisting construction, and are lined with hard burned acid resisting tile which is arranged to completely cover the bottom and the two sides and to provide a center division wall. On the bottom, the tile is given an oval shape so that as the strip moves forward it is supported only on the two extreme edges. This condition remains true for all widths, from the minimum to the maximum. The acid line is maintained several inches above the normal pass line of steel in the maximum widths. It can thus be seen that the leveler has several functions. First, it flattens the steel, removing coil curvature; second, there is a tendency for mechanical cracking of scale; and third, the leveler acts as a feeding device to push the strip forward through the entire length of the 45 ft. tank. There is a comparatively small volume of acid in the tank at any one time. There is a slot in each end of the tank through which the strip enters and leaves, and this is also arranged as an overflow through which excess acid flows into an overflow chamber, from which it is drained back to a storage tank.

The storage tank is equipped with heating coils and a constant return flow of acid to the pickle tank is maintained by a motor driven, acid proof pump. The return lines are arranged to cause the acid to enter the tank through the center dividing wall, in such a way as to permit the acid to flow toward both ends. It can

IS HEAT SLOWING UP YOUR WORKMEN?



TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 inch sizes.

Keep Them COOL with TRUFLO FANS

TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
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TRUFLO FAN COMPANY
554 MAIN ST., HARMONY PA.

thus be seen that a constant circulation of acid is maintained and the flow is sufficiently strong to break up any formation of hydrogen bubbles. The flow is also sufficiently rapid so that every square inch of the steel strip is in contact with moving acid. This is made possible by the fact that the steel strip is supported only on the extreme edges and therefore the full area of the top and bottom surfaces is exposed to the flow of the acid. In this respect the action is much better than that of the continuous pickler, in which the only agitation of the acid is accomplished through the injection of steam, which by its action, maintains only a localized movement of the acid.

Another objection to the conventional continuous pickler is that the acid is being constantly diluted by the steam condensing and thereby weakening the acid. In the United type machine the steam is confined to a series of lead coils placed in the large storage tanks, and the acid is therefore not weakened due to the condensation of steam, and since the acid is mechanically circulated it does not rely upon the agitation produced by steam alone.

Upon reaching the end of the first acid tank the strip passes through a slot and is carried by means of guides to a pair of rubber covered rolls, which act as squeegees and thus prevent excessive acid carry-over and at the same time these rolls drive the strip forward into a second 90 ft. tank, the action of which duplicates that described for the 45 ft. tank.

Upon leaving the 90 ft. tank a second set of rubber covered rolls is encountered which again squeegee the surface and drive the strip forward through a short cold water tank similar in construction to that described for the acid tank. The cold water is circulated much the same as the acid, except that a valve is introduced into the line which permits the wasting of a pre-determined percentage of the water and thus prevents an excessive acid build-up. Upon leaving this tank, another pair of driven squeegee rolls is encountered, which drive the strip forward to a hot water rinse tank, which is also re-circulated. This tank may contain hot water only, or it may contain a solution of hot water and soluble oil, with a small percentage of engine oil.

The advantage of the oil solution is that the strip emerges completely oiled with a soluble solution similar to that usually employed in the coolant system for the cold mills, which usually follow the pickling operation. From the hot water tank the strip passes through a hot air dryer and then directly into a three-roll type coiler. As quickly as the coils are formed they are ejected by an air operated stripper into a gravity type conveyor which carries the pickled coils into the cold mill building.

The pickler has been designated as semi-continuous. It differs from a full continuous line due to the fact that the strip is pushed rather than pulled through the various tanks and therefore does not require stitchers or welders, leader strips or looping pits, and consequently does not require shears to remove stitches or welds. It can be taken out of operation by simply stopping the motor driven pumps or inversely it can be put into operation by starting the pumps.

In all cases the pickle and rinse

PHOTOGRAPH COURTESY THE AMSLER-MORTON COMPANY

Rule of thumb steel making

COSTS TOO MUCH TODAY

DAYS when guesswork could be tolerated in a steel mill belong to the past—guesswork costs too much today. Spoilage—lost time and material—inefficient operation—these things rob a plant of profits.

Good steel men no longer depend on a "guess" to control Combustion Conditions in a furnace, an open hearth or a soaking pit. It spoils steel, wastes fuel—cuts down profits.

Hays Combustion Instruments have set the standard for accuracy, dependability and stamina for 38 years. They are as well known in the steel mills and power plants of the country as a monkey wrench. They can be designed to meet practically any requirement concerning indicating, recording and controlling of combustion conditions. Hays Engineer-representatives are located in all the principal cities to help industry in the solution of its combustion problems. They will be glad to serve you. Write to 955 Eighth Ave., Michigan City, Indiana.

The HAYS CORPORATION
SINCE 1903 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

tanks are covered with sealed covers and at the only points from which fumes may emerge, that is, at the ends where the open slots provide means for acid circulation, over-head ducts carry any objectionable fumes outside the building.

There are many variations which can be made from the above construction to conform to the particular requirements of the individual customer.

BACK-UP BEARINGS HAVE HIGH CAPACITY

▲ Four Timken tapered roller bearings installed on the back-up rolls of the new, 4-high, reversing hot mill of Aluminum Company of America mill at Alcoa, Tennessee, have 30 per cent more capacity than any bearings ever built before.

These bearings have a 35½ in. bore by 51 in. outside diameter by 36 in. width. They weigh 9070 lb. each and have a mill separating force capacity of 8,300,000 lb. at mill speed.

Each bearing is a four cage assembly with 34 machine turned, case carburized rolls per cage, or a total of 136 rolls per bearing. Individual rolls are 4 in. in diameter, 7¼ in. long and weigh 23.37 lb.

The cones and cups are forged. The cages are turned.

FABRIC BEARINGS FOR CRANE WHEELS

▲ The Gatke Corporation, 228 N. La Salle St., Chicago, announces development of special moulded fabric bearings for crane track wheel, trolley and line shaft service.

Compared with conventional bearings, it is claimed these special fabric crane bearings give many times longer serivce—have 50 per cent less starting friction—and 30 per cent less running friction. Lubrication is much less critical, and the bearings do not score journals. Even if lubrication fails, journals are not damaged.

These special fabric bearings also withstand shocks and impact loads that fatigue metal bearings.

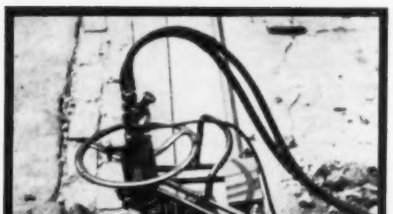
Gatke fabric bearings are non-corrosive and withstand fumes that destroy metal bearings. They also withstand dirt, dust and neglect much better than conventional bearings. They are giving excellent service on installations where roller bearings have proved entirely impracticable and conventional bearings give extremely limited service.

Gatke fabric crane bearings are moulded to finished dimensions in all shapes and sizes for replacing conventional bearings without changes.

RAILS SALVAGED FOR SCRAP VALUE

▲ Indications are that a tightness in available scrap, especially of the proper grade, is becoming a serious threat to the national defense program through forcing a curtailment of steel ingot production. Steel mills cannot produce full-capacity tonnage because they must use low-grade melting steel; and they are being forced to dip deeply into their inventories of scrap, reducing them to an abnormally low point, at a time when they would normally be building up their stocks for the winter months.

In the light of this condition, a thought should be passed on to steel



Oxy-acetylene cutting machines are used for reclaiming scrap metal from abandoned car tracks.

mills, municipalities, and various types of traction companies, pointing out that thousands of tons of scrap rail can be obtained by the removal of abandoned streetcar tracks which are now embedded, unused, in the streets of hundreds of cities throughout the country. Furthermore, the removal of these rails can be economical and efficient through a method, recently developed, in which a portable, oxy-acetylene cutting machine is used.

Aside from the simplicity and high speed of cutting, which make this method so efficient, there also are economies which can be realized from adopting this method. It permits removal of the rail without breaking adjacent pavement, even when the asphalt, macadam, stone blocks, or brick has been laid flush with the top of the rail. Thus, even from the standpoint of the municipality or the streetcar company, this method should be attractive. Repaving costs are kept at a minimum, and cost of removal is more than covered by the sale of the scrap rails.

Only **1** **STUFFING BOX... AND THAT EASILY PACKED**

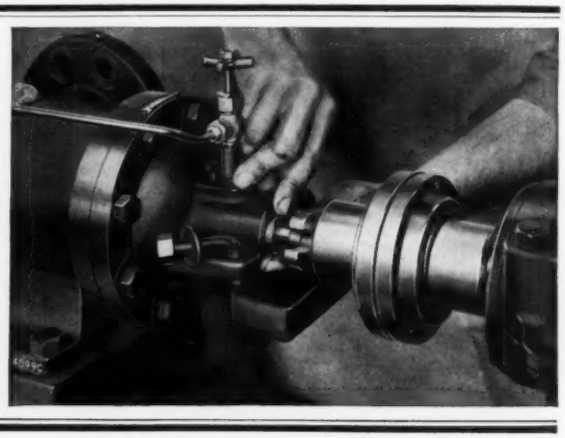
The stuffing box of the

DE LAVAL-IMO OIL PUMP

is under suction pressure and is directly accessible. There are neither valves nor gears and only three moving parts. Oil of any viscosity is delivered against any pressure without vibration, shock or pulsation, and the pump operates at standard motor, or turbine speeds. *Write for Catalog 1-73.*

IMO
I MOVE OIL

IMO PUMP DIVISION
of the De Laval Steam Turbine Company
Trenton, New Jersey



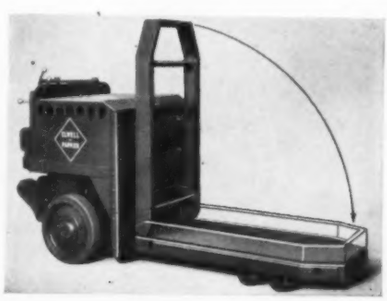
In this method, the cutting machine is positioned on a special track; two or more sections of such a track can be used so that the cutting operation can be carried on continuously. The cutting blowpipe of the machine is equipped with a bevel-cutting nozzle, and a single cut is made at an angle along the groove of the rail so that the top of the rail is severed from the web in two longitudinal sections. The cut rail can then be easily removed with a pinch bar.

The careful investigation of all sources of scrap material is one of the most important steps which can now be taken to avert a scrap crisis. Abandoned tracks provide one such source which should be considered, especially now that a simple method for removing the track has been developed. And the utilization of this rail should go a long way toward alleviating the present situation and keeping steel mills at full capacity.

LIFT TRUCK FOR VARYING CLEARANCE

▲ A recent addition to the platform structure of an Elwell-Parker type EP-4 power industrial truck enables the operator to pick up, transport and place loaded skids having various under-clearances, without wasting time.

The standard height of truck platform is 6 in. above floor, with a 4½ in. lift. This permits lifting and handling skids having an under-floor clearance of 7 in. To handle skids of greater



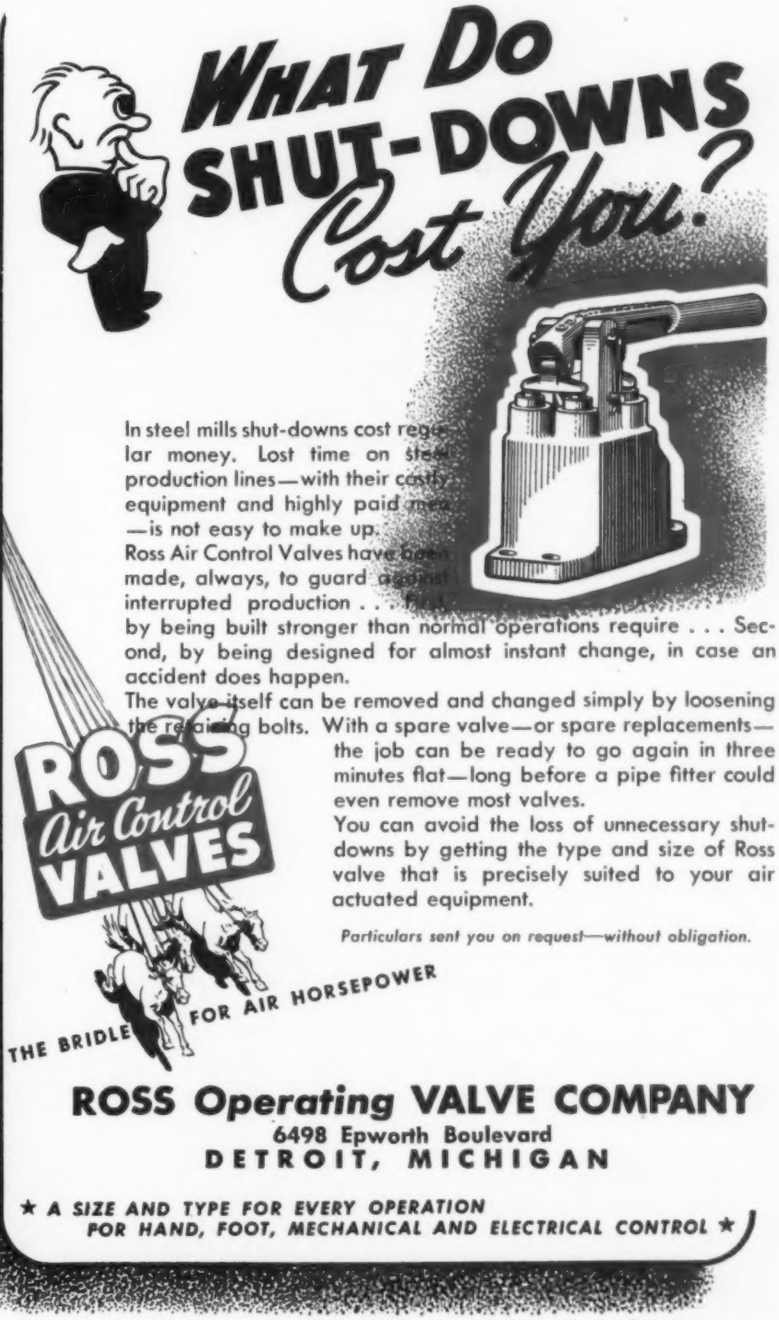
height, a hinged frame or superstructure is lowered from its vertical position, increasing the platform height to 11 in. at normal, and 15½ in. when raised.

Thus a single truck with this or a deeper attachment could handle skids varying from 7 in. to 22 in. or even higher, with equal facility. Furthermore, owners can extend the usefulness of present skids whether for hand or power lift instead of discarding them at once.

The truck is designed for storage battery operation. Rated capacity is 4000 lb., travel speed under load, 4¾ mph. Two-wheel drive, 6-wheel steer. An independent motor controls lifting and lowering of platform.

Safety features include an automatic cutout at extreme limits of platform travel and an adjustable, self-operating slip clutch which operates in case the platform encounters an obstruction during elevation and a swing link should load or platform foul when being lowered.

Dynamic brake supplements the friction brake and foot pedals are interlocked with the drive controller. When depressed, one pedal closes the power circuit while the other releases the brake, giving operator complete control of truck on ramps. When operator leaves his station, pedals spring up, opening the power circuit and locking the wheels. No fuses are used in the power circuit.


WHAT DO SHUT-DOWNS Cost You?
In steel mills shut-downs cost regular money. Lost time on steel production lines—with their costly equipment and highly paid men—is not easy to make up.
Ross Air Control Valves have been made, always, to guard against interrupted production . . . first by being built stronger than normal operations require . . . Second, by being designed for almost instant change, in case an accident does happen.
The valve itself can be removed and changed simply by loosening the retaining bolts. With a spare valve—or spare replacements—the job can be ready to go again in three minutes flat—long before a pipe fitter could even remove most valves.
You can avoid the loss of unnecessary shut-downs by getting the type and size of Ross valve that is precisely suited to your air actuated equipment.
Particulars sent you on request—without obligation.
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THE BRIDLE FOR AIR HORSEPOWER
ROSS Operating VALVE COMPANY
6498 Epworth Boulevard
DETROIT, MICHIGAN
★ A SIZE AND TYPE FOR EVERY OPERATION FOR HAND, FOOT, MECHANICAL AND ELECTRICAL CONTROL ★

ITEMS OF INTEREST

John W. Bates, formerly superintendent of the Irvin works 80 in. hot strip mill, has been appointed assistant to the general superintendent of the Homestead, Pennsylvania, works of Carnegie-Illinois Steel Corporation. He has been associated with United States Steel Corporation subsidiaries for 14 years.

Mr. Bates was graduated in electrical engineering from Alabama Polytechnic Institute in 1924, and subsequently attended Geneva College. His career includes service with the American Telephone and Telegraph Company at Atlanta, Georgia, and with the Duquesne Light Company at Pittsburgh, Pennsylvania. He joined the former American Sheet and Tin Plate Company at Pittsburgh as a power engineer, July 1, 1927, and in 1936, became electrical estimator for Carnegie-Illinois Steel Corporation. On June 1, 1937, he was appointed assistant electrical superintendent at Irvin works and two years later became assistant to the superintendent of the hot strip mill. Mr. Bates has been superintendent of the Irvin strip mill since October 1, 1939.

JOHN W. BATES

F. W. Bush has been named assistant manager, electrical department, Allis-Chalmers Manufacturing Company, Milwaukee, and **J. F. Sellers** has been appointed engineer in charge of d-c. design. The sales section, transformer division, will henceforth be divided in two sections, with **G. W. Clothier** in charge of transformer sales and **R. Bell** in charge of feeder voltage regulator sales.

Fred H. Haggerson, vice president, Union Carbide and Carbon Corporation, New York, has been elected a director of the company. Mr. Haggerson is also president of Union Carbide Company and president of the companies in the electro-metallurgical group. He has been with the corporation for more than 20 years.

O. K. Marti has been appointed consulting engineer, rectifier division, Allis-Chalmers Manufacturing Company, Milwaukee. **H. Winograd** has been named engineer in charge of rectifier design, and will assume some of the duties Mr. Marti is relinquishing.

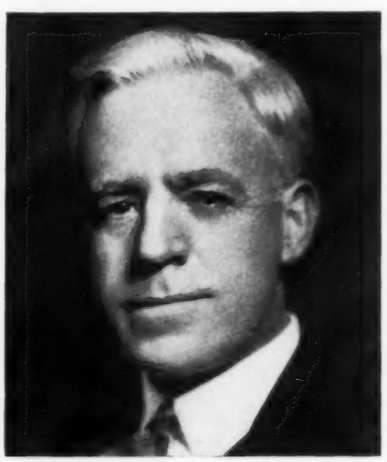
Harry L. Erlicher, vice president, General Electric Company, Schenectady, New York, and also in charge of that company's purchasing activities, has been named a member of the Defense Industries Advisory Committee of the Copper and Zinc Industries, a division of the Office of Production Management. Previous to his new appointment, Mr. Erlicher was the industrial user's representative of the Nonferrous Metals Priorities Committe, OPM.

John A. McDonald, formerly associated with Republic Steel Corporation at Youngstown, Ohio, has been named assistant blast furnace superintendent, Hanna Furnace Corporation, Buffalo.

Howard M. Hubbard has been elected president, Elliott Company, Jeannette, Pennsylvania, manufacturer of power plant equipment, effective September 1. He was formerly president, Greenfield Tap and Die Corporation, Greenfield, Massachusetts.

F. J. Martin has been named general superintendent of the company's Duluth works and **J. C. Witherspoon** has been made assistant general superintendent. Mr. Martin has been superintendent of the hot mills and finishing mills, while Mr. Witherspoon was superintendent of the steel works.

D. G. Baxter is appointed general superintendent in charge of the Copperweld Steel Company's Warren, Ohio plant. Mr. Baxter is a graduate of Ohio Northern University and is widely known in the steel business. He had previously been associated with American Steel and Wire Company, Pittsburgh Crucible Steel Company, Republic Steel Corporation, and the National Tube Company.



D. G. BAXTER

(*Please turn to page 148.*)

HANDLE STEEL FASTER

with easily-maneuvered Electric Fork Trucks— one of 6 distinct types built by Elwell-Parker

Supplying Power Industrial Trucks, Tractors and Cranes to handle any tonnage faster and more economically, is only one part of Elwell-Parker's far-reaching service to the Steel Industry.

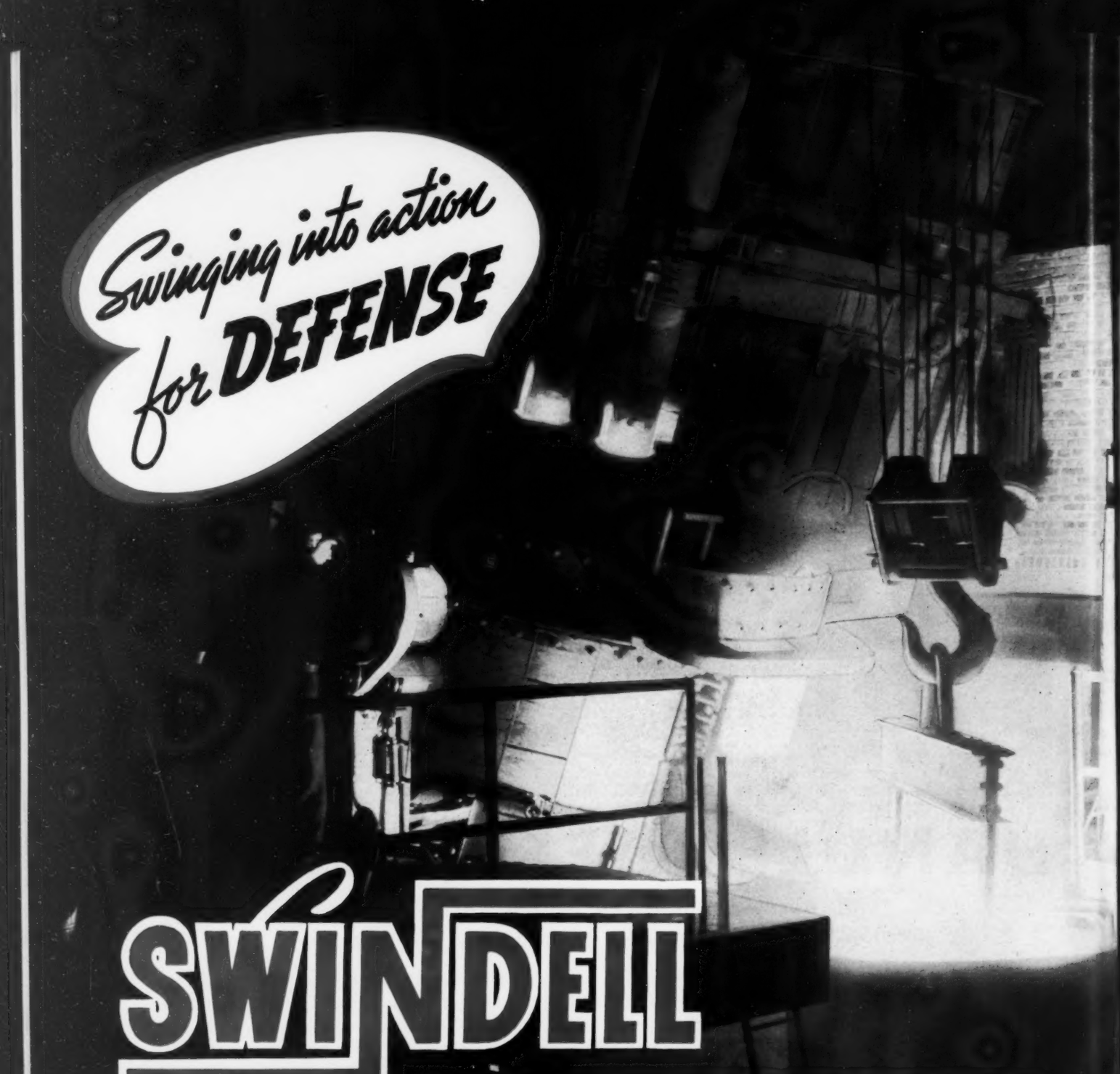
Helping you to adapt Systems of load transportation, drawing upon complete Elwell-Parker lines of Center Control and End Control Fork Trucks, Platform Trucks, Lift Trucks, Cranes, Tractors and Load Carriers, is equally vital in reducing your costs of transporting mill loads.

Center Control Fork Trucks (above) are matched by equally modern Elwell-Parker End Control Units. Attachments include telescoping uprights; lifting-tiering-tilting; and interchangeable rams, forks, booms, roll-handling aprons, upenders and scoops.

Elwell-Parker's successful Truck-building experience covering more than 35 years, is available through the services of our Steel Transportation Engineers. They will help you plan and install a complete System guaranteed to create minimum costs of transportation under your present capacity production. The Elwell-Parker Electric Co., 4504 St. Clair Ave., Cleveland, O.

ELWELL-PARKER *Power Industrial* TRUCKS

ESTABLISHED 1893 • BUILDING POWER INDUSTRIAL TRUCKS SINCE 1906



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SWINDELL

Electric MELTING FURNACES

In the service of an Eastern steel producer, this typical SWINDELL furnace brings to the urgent work of defense *superior performance* . . . with a top-charge swinging roof which saves time and labor, prolongs refractory life, and assures a full furnace . . . *plus* Swindell Unitized Construction of furnace body, roof lifting unit, roof and electrode structure . . . providing perfect alignment and smooth operation.

For more facts on *your* application, *call Swindell!*

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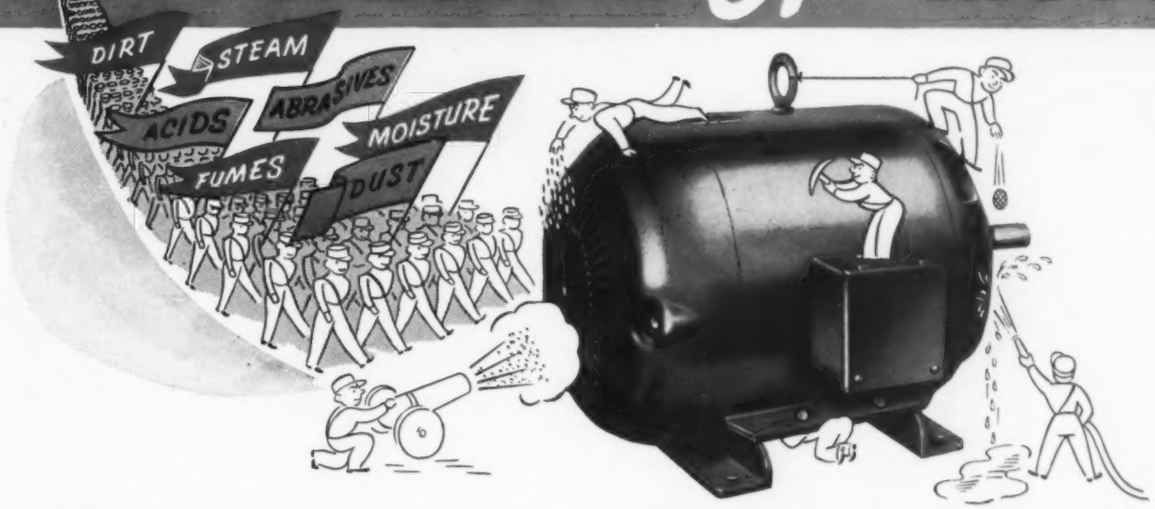
DESIGNERS AND BUILDERS OF MODERN FURNACE EQUIPMENT SINCE 1850

PITTSBURGH, PA.

These "FIFTH COLUMNISTS" don't stop WAGNER CP MOTORS

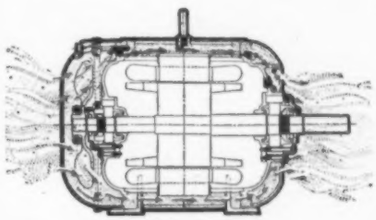


In every steel plant you can find these fifth columnists – dirt, dust, fumes, acids, abrasives, chips and filings, hard at work spreading destruction to open-type motors and slowing down defense work because of motor failure.

With Wagner CP totally-enclosed fan-cooled motors on the job in your plant, you need not fear these fifth columnists because the motors are built to ward off these destructive agents.

Thousands of CP motors are giving completely satisfactory service on defense jobs of all kinds. This is your assurance that they will do their part in keeping your plant operating at top capacity.

Wagner type CP totally-enclosed fan-cooled motors have two frames: an outer frame which guides a strong cooling draft over the motor, and an inner frame which protects the vital parts of the motor against the entrance of destructive agents. Ball bearings are used throughout. Cartridge completely seals bearings against dust and dirt when the rotor is assembled in, or removed from, the motor. End plates are concentrically machined to exact dimensions for perfect stator-frame fit.



Twenty-five sales and service branches located in principal cities, enable the Wagner Electric Corporation to keep in close contact with its many customers. Trained sales engineers are ready to assist you in selecting the proper motor for your particular need.

50 YEARS OF SERVICE

This year Wagner celebrates its fiftieth year of service to industry and the home – as a manufacturer of motors, transformers, and fans of the highest quality.

WAGNER ELECTRIC CORPORATION 50TH 1891 • 1941 ANNIVERSARY ST. LOUIS, MO.

Bulletin MU-182 completely illustrates and describes the construction details as well as the electrical characteristics of Wagner CP Motors.

Send for your copy today

M41-24C

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

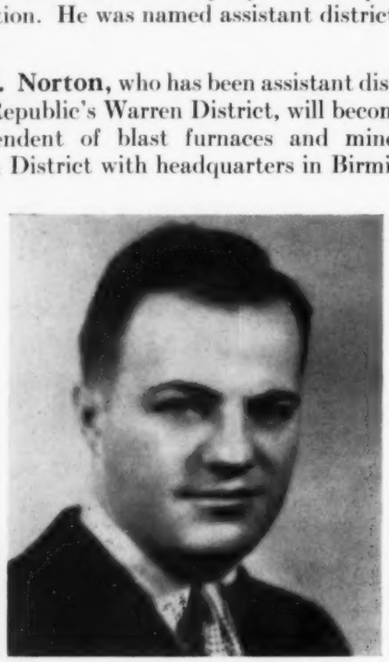
MOTORS • TRANSFORMERS • FANS • BRAKES

A. G. Delaney, now assistant district manager for Republic Steel at Gadsden, will become general superintendent of Republic's steel mills at Gadsden.

Mr. Delaney was born in Evanston, Illinois, and studied mechanical engineering at Georgia School of Technology and hydraulic engineering at Ohio State University. He was a construction engineer and superintendent of construction for eight years with Dwight P. Robinson Company, working both in the United States and South America. He also was employed for eight years with the Gulf States Steel Company as construction engineer and superintendent of maintenance, retaining that position following the merger of the Gulf States Steel Company with Republic Steel Corporation. He was named assistant district manager in 1939.

A. G. DELANEY

B. W. Norton, who has been assistant district manager in Republic's Warren District, will become general superintendent of blast furnaces and mines in the Southern District with headquarters in Birmingham.



B. W. NORTON

Mr. Norton was born in Wilkinsburg, Pennsylvania, in 1903, graduated from Penn State College in 1925 and started to work for Republic Iron and Steel Company in the coke plant the same year. He was transferred to the blast furnace department in 1926 and was made assistant superintendent of blast furnaces in 1929. In 1930 he was made superintendent of blast furnaces, in 1933 was appointed superintendent of blast furnaces and coke plant, subsequently becoming assistant district manager of Republic's Warren District.

Edward I. Evans, district manager of Republic's Gulfsteel District, has been placed in charge of a newly created Southern District, which will include operations in both Gadsden and Birmingham.

EDWARD I. EVANS

WORLD'S GREATEST all around ELECTRIC TOOL

DRILLS—GRINDS—SANDS
SAWS—POLISHES
SHARPENS—CARVES

The new WHIZ ELECTRIC TOOL is the handiest power tool ever made. A rugged tool for power and precision work. Drills through ¼ inch iron plate in 42 seconds or engraves intricate designs. Handles any material: Metals—Woods—Alloys—Plastics—Glass—Steel—etc. Saves time. Eliminates labor. Plug into any socket AC or DC, 110 volts. Chuck ¼ inch capacity. Ball bearing thrust. Powerful, triple-geared motor. STANDARD MODEL, with Normal Speed (uses 200 different accessories, instantly interchangeable). **Price only $7.95.**

The only DRILL-TOOL with a full year's guarantee

FREE Accessory outfit (Value $2) includes set of drills, mounted 1½ inch grinder, sanding discs, cutting wheels, mounted brush, polishing wheel, carving burr, etc. FREE with each tool ordered NOW. We pay postage.

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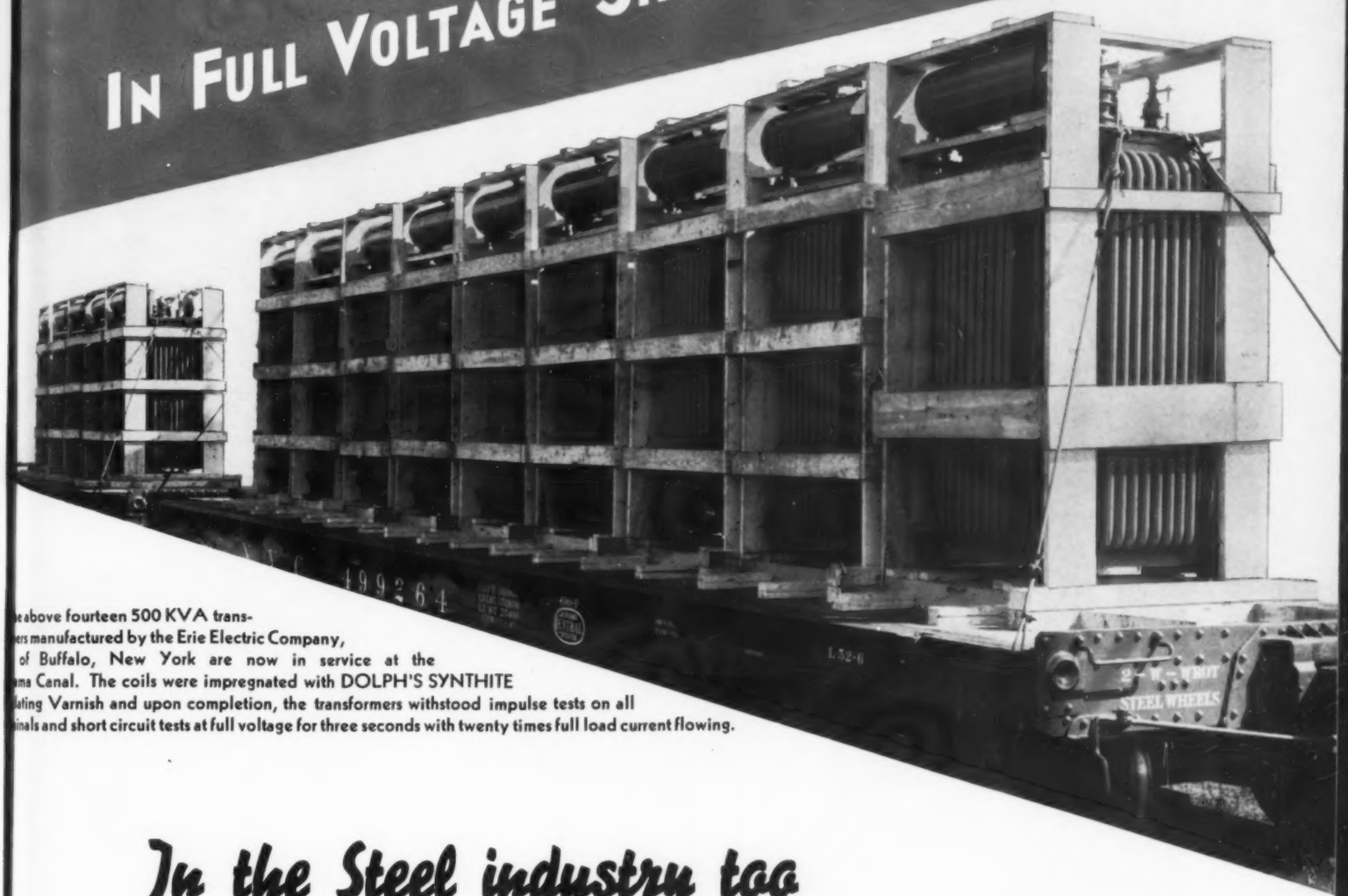
SYNTHITE INSULATING VARNISH PROTECTS TRANSFORMER COILS IN FULL VOLTAGE SHORT CIRCUIT TESTS



e above fourteen 500 KVA trans-
ers manufactured by the Erie Electric Company,
of Buffalo, New York are now in service at the
ma Canal. The coils were impregnated with DOLPH'S SYNTHITE
ating Varnish and upon completion, the transformers withstood impulse tests on all
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In the Steel industry too

Transformers, motors and electrical equipment must withstand severe tests, not within the laboratory, but under the unsparing operating conditions found in modern sheet and strip mills.

DOLPH'S SYNTHITE Insulating Varnish has proven its ability to protect motor windings against the ravages of iron dust, dirt, oil and water and has insured dependable motor operation in the face of these hazards coupled with the overload so often necessary in today's operation.

The facilities of our electrical and chemical laboratories are available to industry without obligation and DOLPH Sales Engineers welcome the opportunity to assist in the selection of the right DOLPH Insulating Varnish to meet any specific requirement.

JOHN C. DOLPH CO.

INSULATING VARNISH SPECIALISTS

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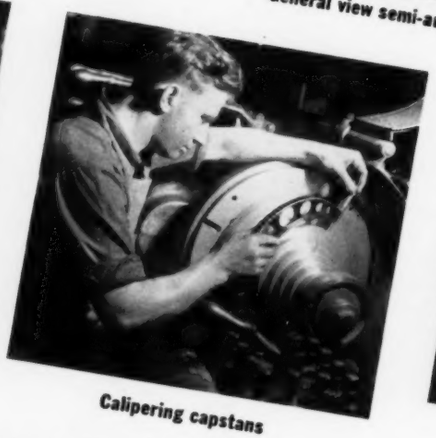
VAUGHN's precision manufacturing —

72" x 20-ft. planer machining Motoblox housings

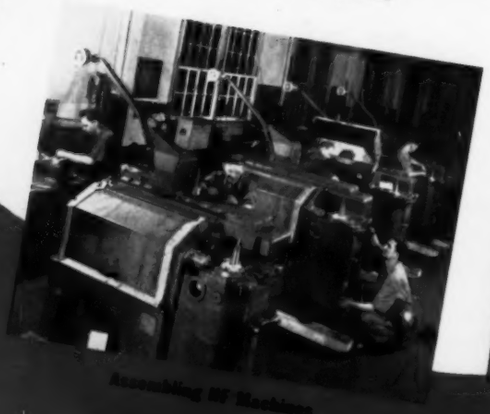
General view semi-automatic lathe department

Checking intermediate Motoblox drawing block



Calipering capstans

Boring mill operation



Assembling RF Machines

Drill presses on various operations

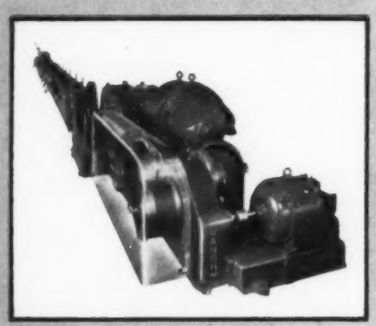
COMPLETE COLD DRAWING EQUIPMENT—CONTINUOUS O3 SINGLE HOLE . . . FOR THE LARGEST BARS AND TUBES . . . FOR TH

PRECISION

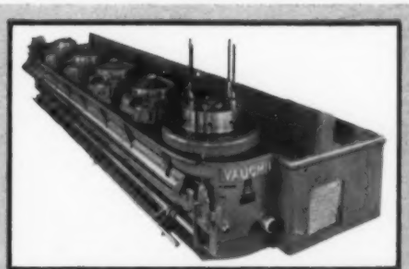
prepares you for PERFORMANCE

VAUGHN

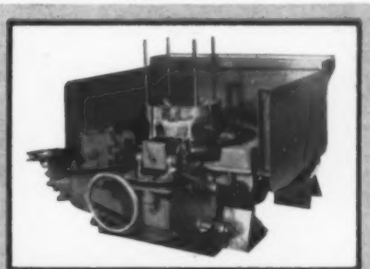
You will find, in the complete range of Vaughn Cold Drawing Equipment, the *right* production machines for *whatever you make in wire*—faster, more versatile, better-built and entirely dependable! From original design to final assembly Vaughn Machinery is produced by leading engineers in the field, the most advanced fabricating facilities, and a rigid system of continuous inspection under full engineering control. Vaughn Machinery is *right* when you get it—and *right* always for your most stringent demands. We invite your inquiries!



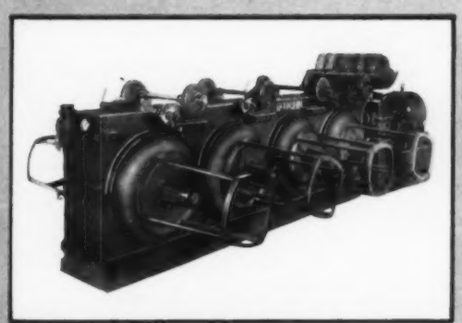
50,000 lb. draw bench



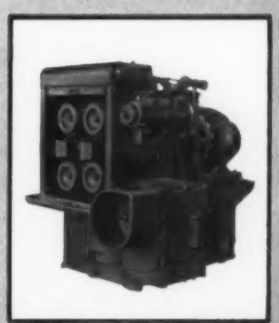
5/6-HR Motoblox, air and water-cooled



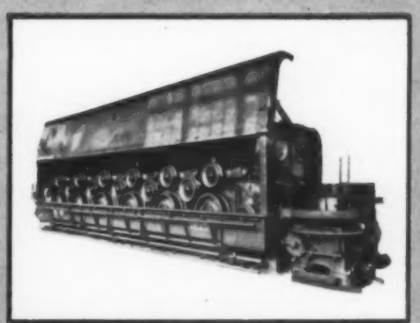
No. 13 D. D. air and water-cooled Motoblox



Take-up frames



4-Cone Continuous Machine —copper, brass, bronze, etc.



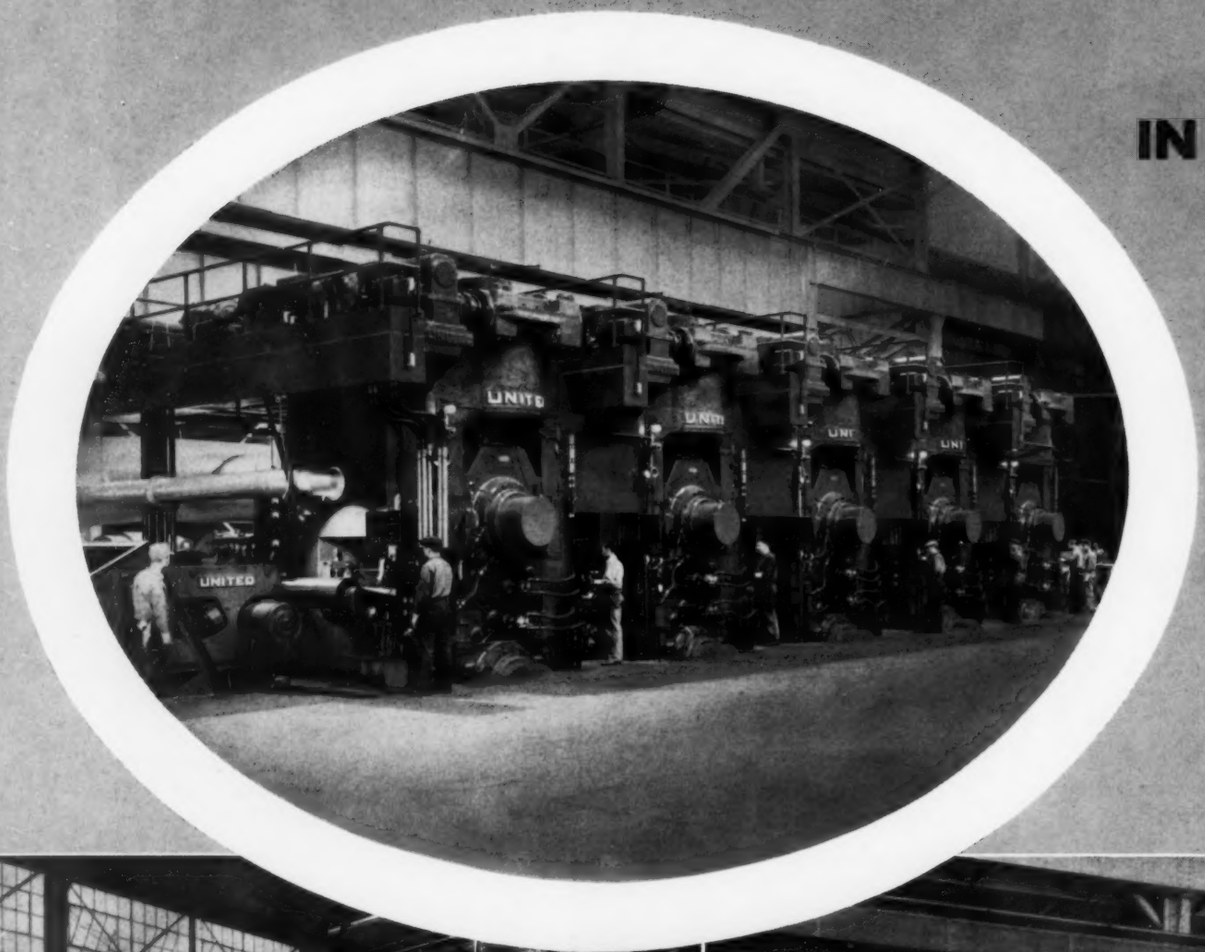
7-HRH Motoblox—copper and special alloys

The VAUGHN MACHINERY COMPANY

CUYAHOGA FALLS, OHIO, U.S.A.

...ALLEST WIRE . . . FERROUS, NON-FERROUS MATERIALS OR THEIR ALLOYS

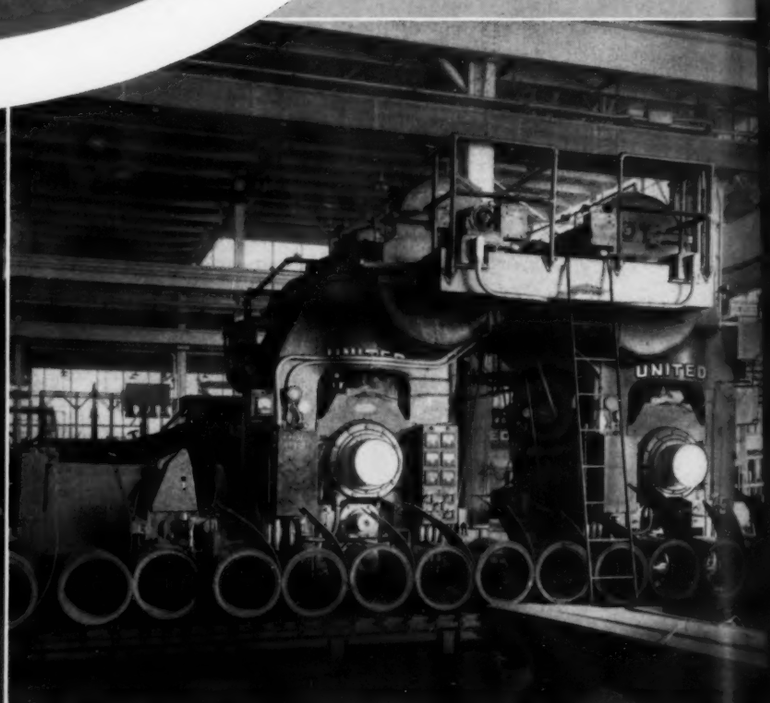
UNITED



IN ALL TYPE

SINGLE STAN
TANDEM
REVERSING, ET

For Steel, Allo
Steels, Tinplat
Copper, Alumi
num, and Othe
Non-Ferrou
Metals

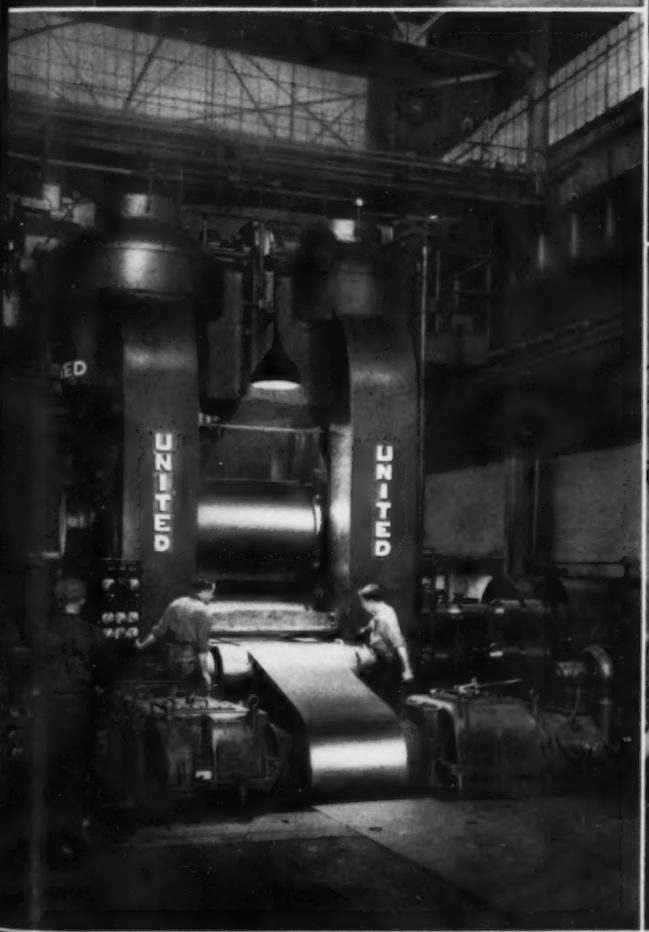


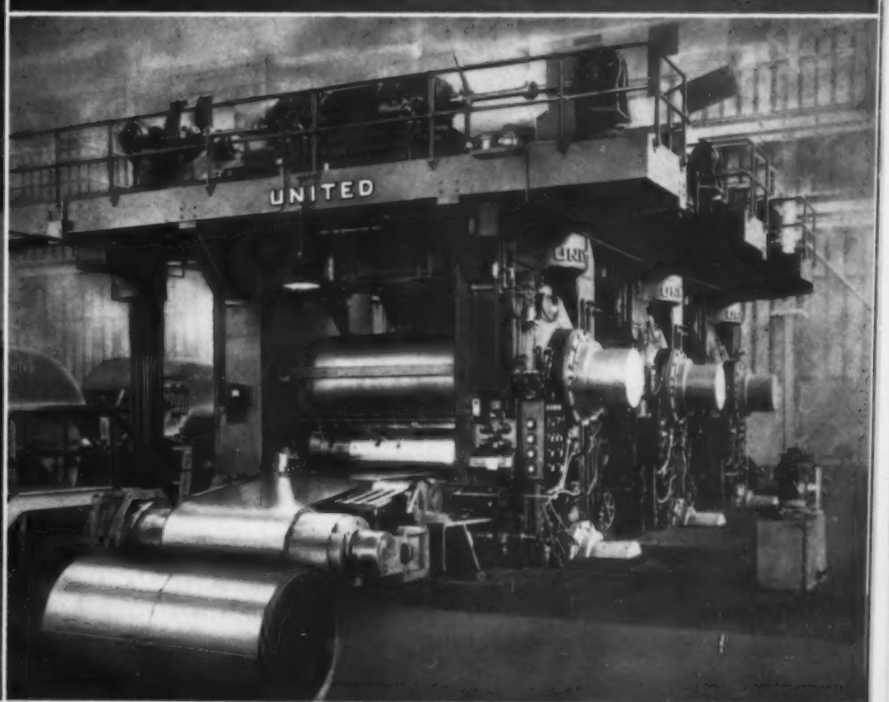
UNITED ENGINEERING *and* FOUNDRY COMPANY

Pittsburgh, Pennsylvania

DAVY
MONTR

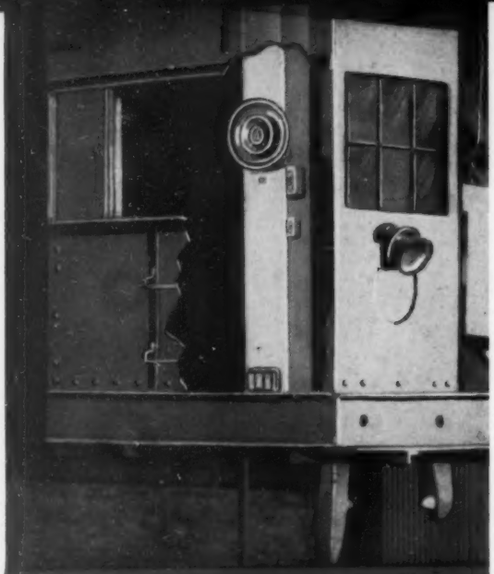
COLD REDUCTION MILLS



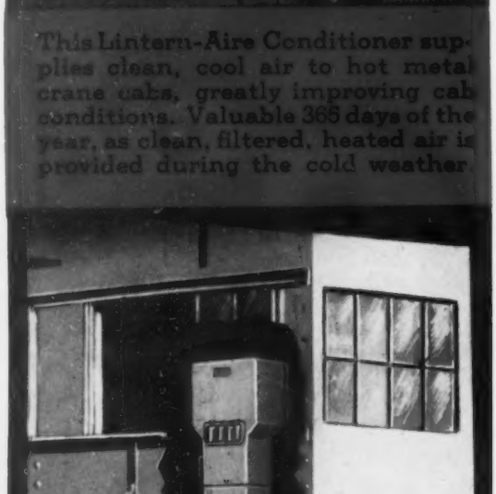


DAVY AND UNITED ENGINEERING COMPANY, LTD., SHEFFIELD, ENGLAND · DOMINION ENGINEERING WORKS, LTD., MONTREAL, P. Q. · UNITED INTERNATIONAL, S. A. PARIS, FRANCE · SHIBAURA-UNITED ENGINEERING CO., TOKYO, JAPAN

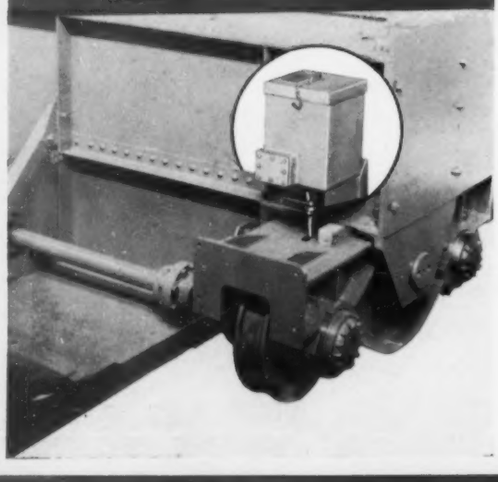
LINTERN-
AIRE CONDITIONERS AND VENTILATING HEATERS
Aid Production



This Lintern-Aire Conditioner supplies clean, cool air to hot metal crane cabs, greatly improving cab conditions. Valuable 365 days of the year, as clean, filtered, heated air is provided during the cold weather.



For general purpose cranes, Lintern Ventilating Heaters supply a large flow of filtered, fast circulating, heated air in even sub-zero weather. In summer, air flow is doubled to give constant air change and effective ventilating.

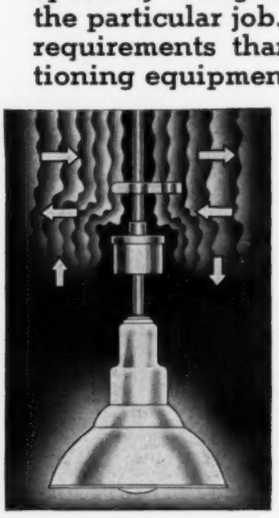


THESE conditioners are proving to be one of the greatest boons ever developed in keeping crane and pulpit operators in condition.

One of the largest steel plants is establishing a program for equipping all of its hot metal cranes, during the coming months, with Lintern Units as a result of proven performance during this past season of extended and excessively hot weather.

The conditioners are for hot metal cranes and pulpits; the ventilating heaters for general purpose cranes — both old and new. Both insure good working conditions regardless of season, severe fumes, gases, heat or cold — and are moderately priced.

Designed and built by competent engineers experienced in steel mill requirements, Lintern-Aire Conditioners and Lintern Ventilating Heaters come in both standard and specially designed units according to the requirements of the particular job. They are more efficient, with less service requirements than general purpose heaters and air conditioning equipment.



Our representatives (listed in catalog E-5) are available at your call to discuss your particular requirements; or, if you prefer, write us direct.

Wherever subjected to vertical or horizontal shocks, lamp life can now be increased as much as 90%. The Lintern Shock Absorber allows both fixture and lamp support to float in flexible sponge rubber effectively absorbing shocks from all directions. Completely eliminates metallic connection between the fixture and vibrating structure.

Equally important to efficient crane operation are Lintern Traction Sanders. Maintaining a constant coefficient of friction, regardless of conditions, that saves armatures, flange wear, crane collisions and even life itself. No sand falling on the product! For either outside or inside service.

Lintern Crane Signals protect lives of operators and crane repairmen. Users find them valuable to the operating man, in signaling at all times the condition of all cranes on the runway.

THE *Lintern* CORPORATION

Day and Night...

WAGNER TRANSFORMERS

ARE FURNISHING DEPENDABLE POWER TO HELP SPEED OUR NATIONAL DEFENSE PROGRAM!

WAGNER transformers have been serving the Steel Industry for 50 years, during which time Wagner has accumulated a vast fund of engineering and manufacturing experience . . . experience that is incorporated in the design and construction of Wagner transformers of today. The value of this experience is reflected in the performance of Wagner transformers. Their high efficiency and complete dependability are the result of half a century of constant improvement.

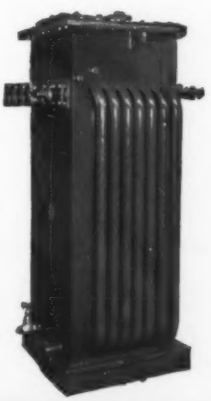
To insure your plant against production delays resulting from transformer failure, specify Wagner when purchasing new transformers. Because of their unfailing performance, Wagner transformers are helping steel plants "set the pace" in the SPEED-UP-PRODUCTION campaign now in full swing.

In addition to power transformers, Wagner manufactures other types of transformers that have special qualifications for steel plant installations, such as the new Noflamol transformer. Wagner Noflamol transformers can be installed indoors without the use of expensive fire-proof vaults, because the liquid in Noflamol transformers is non-inflammable. They can be installed in out-of-the-way places, or on beams up near the ceiling, thereby releasing valuable floor space for other uses.

10,000-KVA Wagner Power Transformer

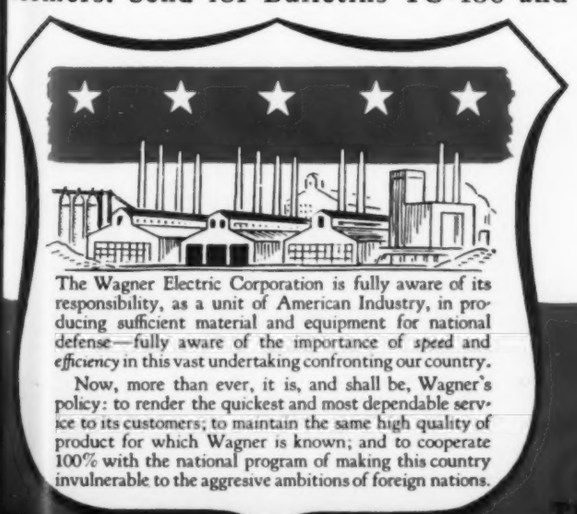
Send for Complete Literature

As a transformer user it is to your advantage to have complete information on all types of Wagner transformers. Send for Bulletins TU-180 and TU-181.



150-KVA Wagner Noflamol Transformer

75-KVA Wagner HEX Transformer



The Wagner Electric Corporation is fully aware of its responsibility, as a unit of American Industry, in producing sufficient material and equipment for national defense—fully aware of the importance of *speed* and *efficiency* in this vast undertaking confronting our country.

Now, more than ever, it is, and shall be, Wagner's policy: to render the quickest and most dependable service to its customers; to maintain the same high quality of product for which Wagner is known; and to cooperate 100% with the national program of making this country invulnerable to the aggresive ambitions of foreign nations.

T41-13A

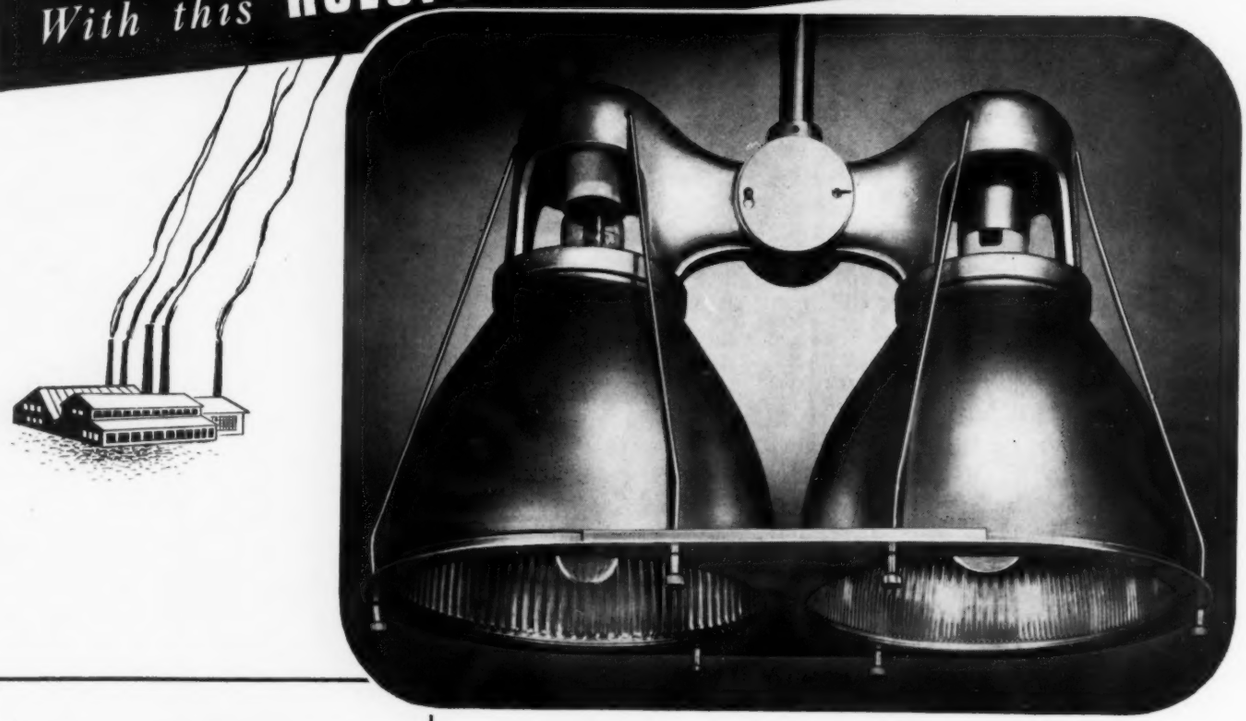
Wagner Electric Corporation

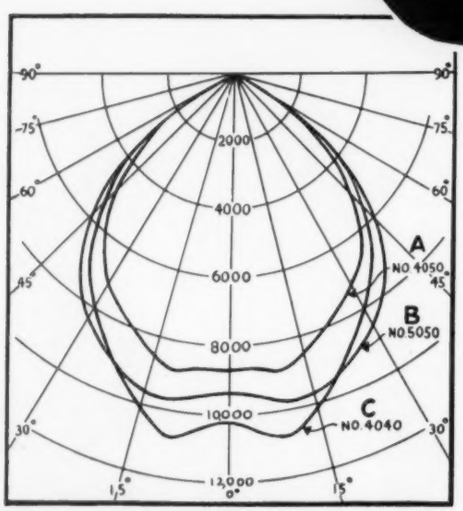
6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

TRANSFORMERS · MOTORS · FANS · BRAKES

LOW COST FOOT CANDLES

With this HOLOPHANE TWIN-MERCURY UNIT





Distribution Curves—(A) 1-400 W. Mercury—1-500 Watt Incandescent Lamp (Unit No. 4050); B-1-400 W. Mercury—1-750 Watt Bi-post incandescent lamp (Unit No. 5050); (C) 2-400 W. Mercury Lamps (Unit No. 4040)

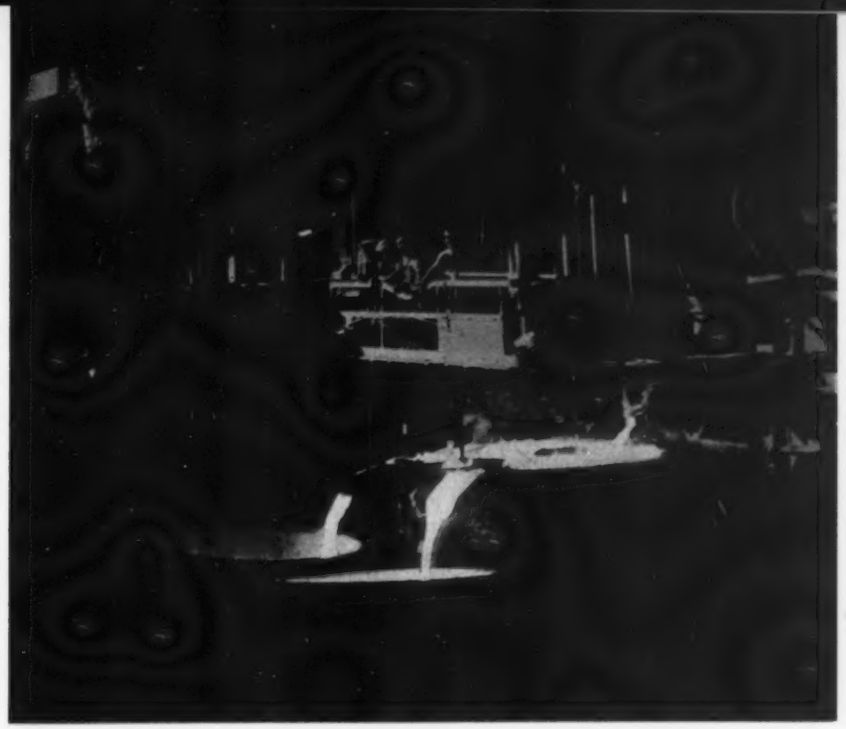
- Gives EFFICIENT MERCURY *or* Combination Mercury Lighting
- Cuts Wiring Cost by Approximately One-half
- Eliminates Stroboscopic Effect
- Gives Excellent Color Blend of Mercury and Incandescent
- Rugged Construction for Steel Mill Service

Let the Holophane Engineering Department make a layout for your next mill extension and compare the cost with the older methods of lighting.

BOOTH 111
IRON & STEEL EXPOSITION

Holophane
COMPANY, INC.
342 MADISON AVE.
NEW YORK CITY

Lighting Authorities—Since 1898
THE HOLOPHANE CO. LTD.
345 Yonge St. Toronto, Canada



MODERNIZE YOUR OPEN HEARTH FURNACES

YOU CAN INCREASE TONNAGE
REDUCE INGOT COSTS
BENEFIT THE QUALITY OF
YOUR PRODUCTS

by using our Improvements, which include

VENTURI PORTS
SLOPING BACK WALLS
DANFORTH-PETERSON CHECKER WORK
FUEL MIXING BURNERS
SODIUM FLUORIDE PROCESS FOR RIMMING STEEL

Open Hearth Combustion Company

GEO. L. DANFORTH, JR., Pres.

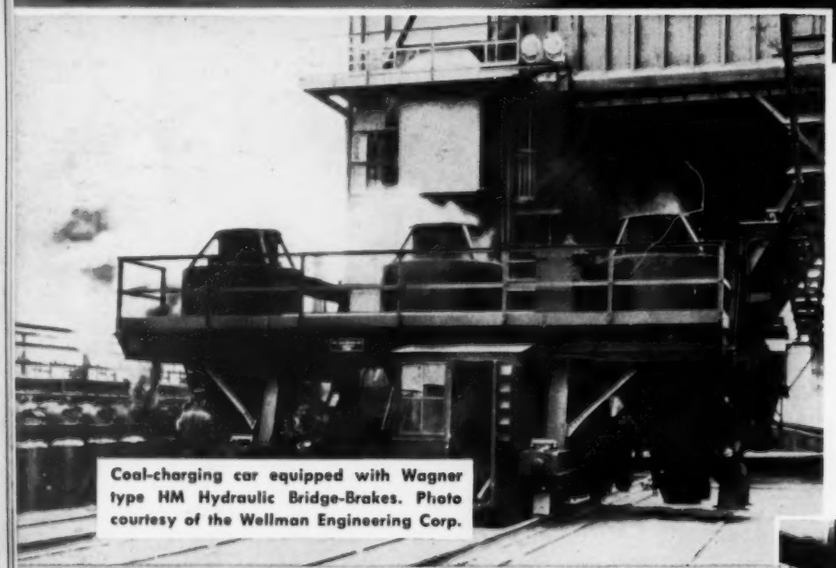
Designers *Licensors* *Engineers* *Consultants*

310 South Michigan Avenue Chicago, Illinois

For Perfect Braking Control and Positive Parkin

Use WAGNER HYDRAULIC BRIDGE BRAKES on coke-oven machinery

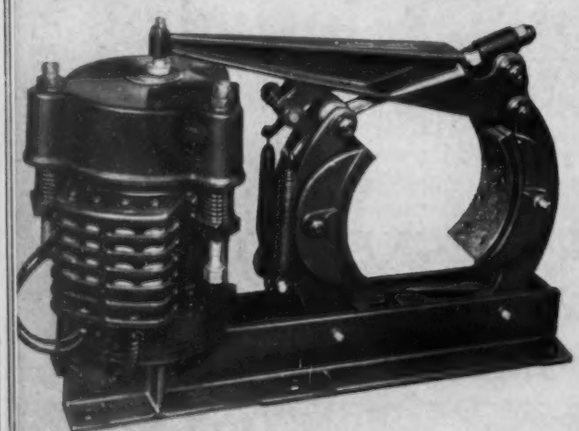
Door machine equipped with Wagner type HM Hydraulic Bridge-Brakes. Photo courtesy of the Wellman Engineering Corporation.



Coal-charging car equipped with Wagner type HM Hydraulic Bridge-Brakes. Photo courtesy of the Wellman Engineering Corp.

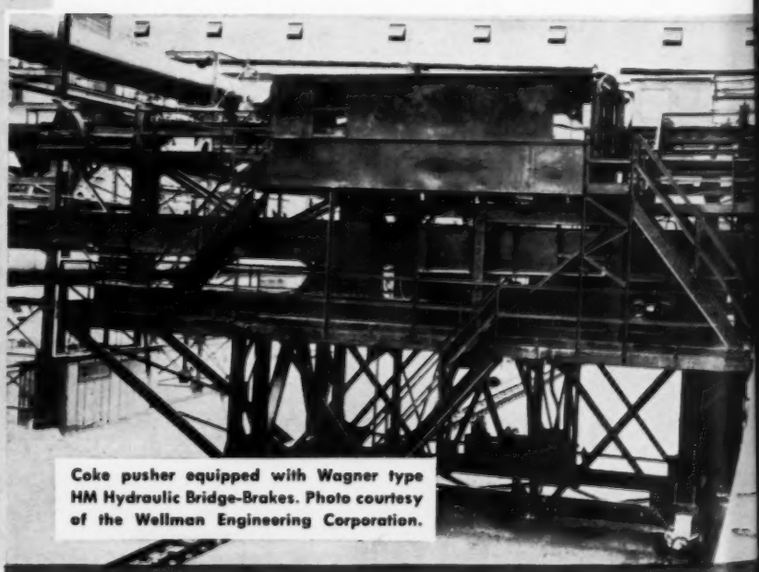
Quick, accurate stopping of coal-charging cars, coke pushers, and door machines is important in all coke plants and particularly so on the newer ovens which require extremely close spotting.

Wagner Type HM hydraulic bridge-brakes are well suited for application to coke-oven machinery. The hydraulic service-brake insures accurate spotting and the automatic parking-brake provides a positive brake which holds the machine in position while charging, pushing, or when not in service.



TYPE HM

Wagner Hydraulic Bridge-Brake with automaticparking attachment. The ideal brake for all coke-oven machinery.



Coke pusher equipped with Wagner type HM Hydraulic Bridge-Brakes. Photo courtesy of the Wellman Engineering Corporation.

SEND FOR BULLETIN IU-20

This bulletin gives you complete information on Wagner Bridge-Brakes and should be in the hands of all production, safety, and maintenance superintendents. Write for your copy today.

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

BRAKES • FANS • TRANSFORMERS • MOTO

OKONITE KNOWS

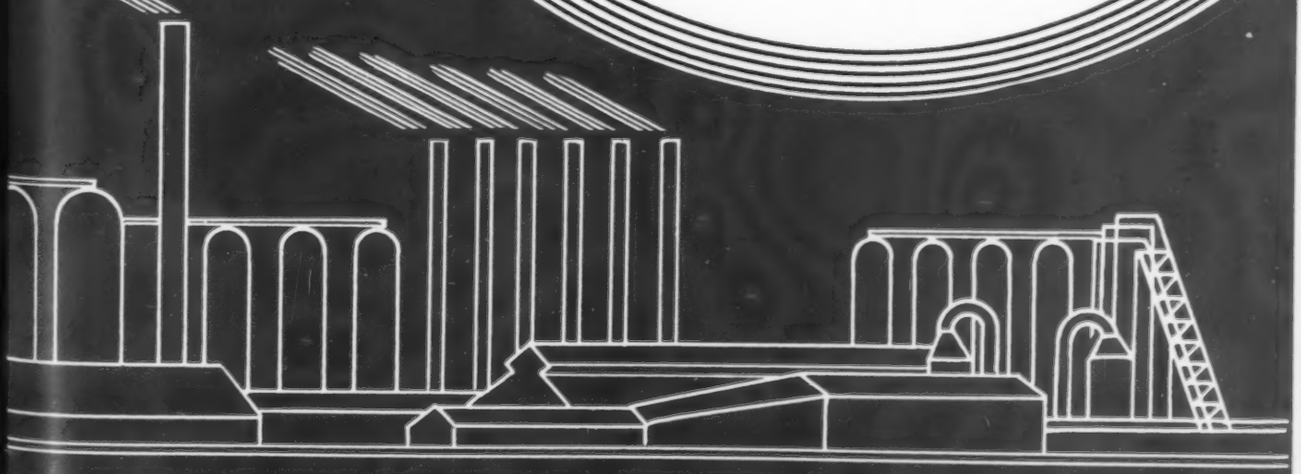
THE INSULATED WIRE AND CABLE PROBLEMS OF THE MODERN STRIP MILL

OKONITE electrical wires and cables, insulated with rubber, varnished cambric, glass, asbestos or synthetics as conditions dictate, are providing the dependable, trouble-free service vital to the maintenance of today's production schedules in many leading strip mills.

Okonite Engineers are always ready to consult with you on any problem connected with the selection of the type of insulation and design of cable best suited to your individual requirements. Write our nearest branch office or communicate direct with

THE OKONITE COMPANY
PASSAIC, N. J.
Offices in Principal Cities

Okonite cables especially favored by steel mill engineers are described on the following page.



OKONITE INSULATED WIRES AND CABLES

OKONITE INSULATED WIRES AND CABLES

OKONITE WIRES and CABLES are available in a wide range of sizes, designs and numbers of conductors and with any desired protective finish.

Rubber Insulated Cables

OKONITE
For Power and Control Circuits

A 30% mineral base rubber insulation outstanding in durability and long life, proved in steel mill service . . . made only from new Up-river fine Para rubber by the unique Okonite Strip Process. Okonite insulation has a tensile strength of 1200 lbs. per sq. inch, a specific gravity of 1.85 and extremely high insulation resistance. It may be used at copper temperatures up to 60° C. (140° F.).

OKOLITE
For High Voltage Circuits

Excels ordinary rubber insulation in providing superior moisture and heat resistance—Okolite cables can be operated at a copper temperature of 75° C. (167° F.) up to 8,000 volts and at 70° C. (158° F.) for higher voltages.

Recommended for voltages up to 35,000 a. c. Requires no lead sheath.

Varnished Cambric Cables

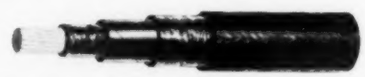
Okonite Varnished Cambric Cables comply with all current specifications . . . are designed for operation up to 85° C. (185° F.) copper temperature . . . retain flexibility under severe operating conditions up to 28,000 volts.

Heat Resisting Cables

OKOGLASS
Non-Combustible Cables

Insulated with rovings of compressed glass fiber and protected with treated woven glass braid for hot locations. Sheathed with lead for protection where moisture is encountered. Okoglass cables last indefinitely where heat or excessive loads destroy other insulations. Available in all sizes for lower voltage applications.

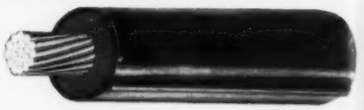
OKOBESTOS
Flameproof, Heat Resistant Cables



Insulated with layers of felted asbestos and Varnished Cambric or with felted asbestos protected by fireproof asbestos braids, Okobestos cables are particularly suited for electric furnace leads, for boiler room and crane wiring and other applications where extreme heat is encountered. Okobestos cables are supplied in all sizes and various constructions for applications up to 5,000 volts.

Special Cables

OKOPRENE
Protected Cables



Sheaths contain at least 60% neoprene. They are applied at the same time as the rubber and vulcanized to it. The resulting bond is airtight and moisture proof. The Okoprene sheath resists sunlight, oil, moisture, ozone and chemical action. Single conductor Okoprene protected cables are available in colors and in all sizes up to 5,000 volts. They are more durable and longer lasting than the best braided cables and cost no more. Also available in multi-conductor designs.

OKOSHEATH
Non-Metallic Cables

Protected with a high grade, tough rubber compound that also does double duty in providing a moisture-resisting, non-metallic protection against mechanical damage. Can be operated under ground outdoors at copper temperatures of 75° C. Light, easy to install and splice, Okosheath cables resist acids and alkalies and are unaffected by electrolysis.

Cable Coverings

Many coverings are available to protect cables from outside damage. They include saturated braids, lead sheaths, wire armor, flat or interlocked metallic tapes, metallic braids, non-metallic armor and Okoloom, a fire hose weave of great strength. Okonite Engineering Service will be glad to suggest the type or design best suited to your needs.

Rubber Sheathed Cords & Cables

OKOCORD
Portable Cords and Cables

Super-flexible Okocords have a 60% reinforced rubber sheath vulcanized in a continuous metal mold. Available in all sizes and constructions from lamp cord to heavy multi-conductor cables up to 3.75 inches in diameter and for service up to 15,000 volts 3-phase grounded neutral.

TYPICAL OKOCORD DESIGNS

TYPE S AND SJ CORDS

WELDING CABLE

MAGNET CABLE

TYPE W POWER CABLE

Tapes and Splicing Materials

OKONITE Rubber Tape

Compounded only from new Up-river fine Para rubber . . . insures highest strength, permanence and moisture resistance.

MANSON Friction Tape

Made only from new rubber and is unequalled in true adhesiveness, aging and weathering qualities.

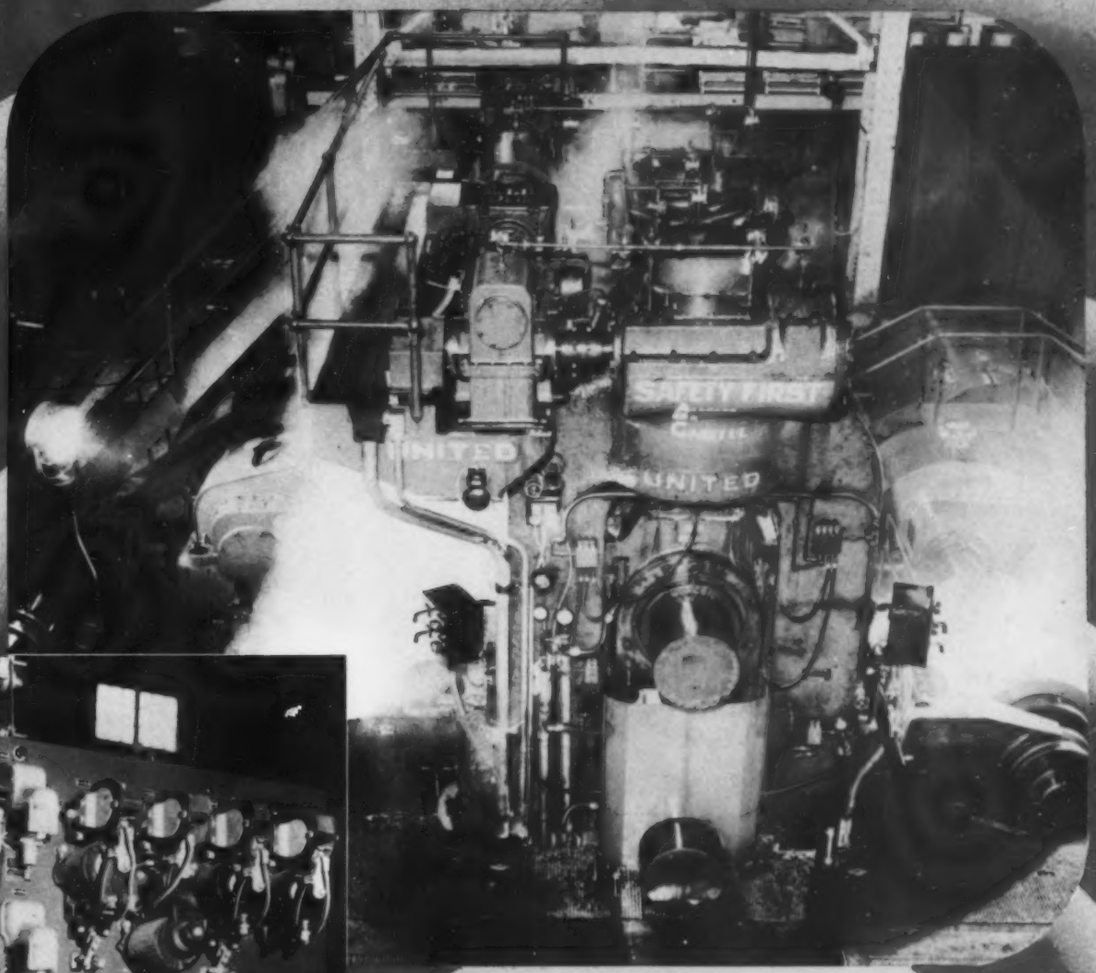
Other Splicing Materials

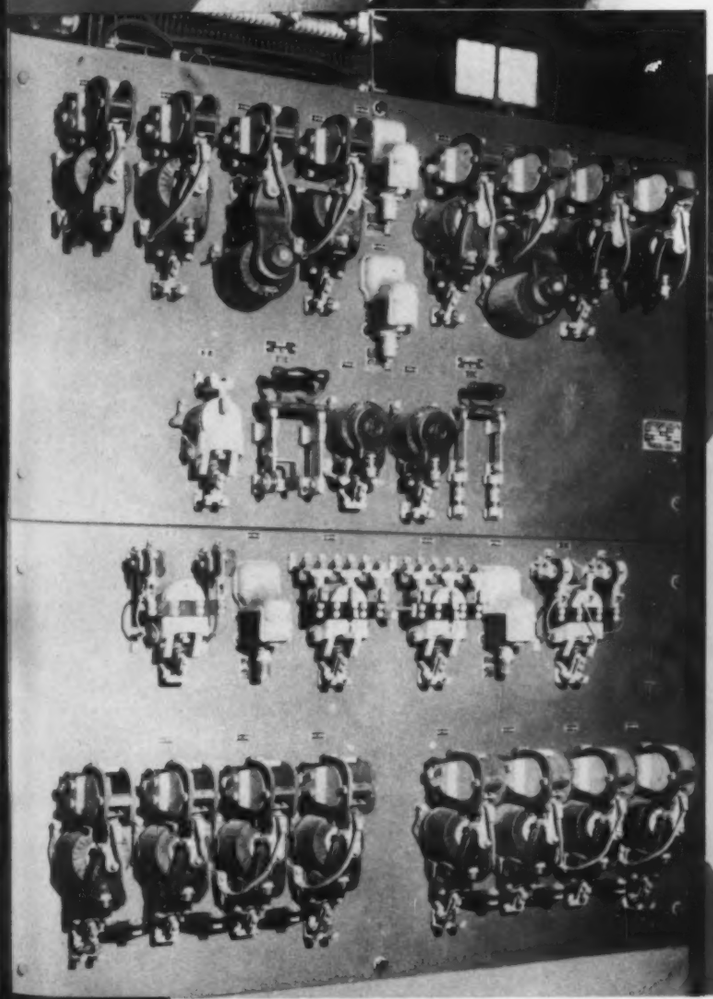
Including unit splicing packages, rubber cement, joint filling compounds . . . in fact everything needed to splice or terminate rubber, paper or V. C. cables of all types.

THERE'S A "3C" CONTROL FOR EVERY AUXILIARY CONTINUOUS STRIPMILL PROCESS

Cold Mill Screwdown with "3C" Bulletin 107 18" D.C. Brakes.

"3C" Special Bulletin 9320 Duplex, Reversing, Dynamic Braking Control Panel.





Two "3C" Bulletin 107 D.C. 18" Brakes provide smooth, positive action with low maintenance and maximum lining life on this Screw Down.

To the left is a Special Bulletin 9320 Duplex Reversing Dynamic Braking Panel for controlling two 35 HP., 230V. D.C. motors.

"3C" Bulletin 7400 D.C. Mill Contactors are built to stand Heavy Duty Service. All Relays have Silver-to-Silver Contacts. "3C" Heavy Duty Type, Vari-Time accelerating Contactors and Relays provide accurate and positive operation with a minimum of control devices on the Panel.

Avail yourself of "3C" Engineering Service . . . by phone, wire, or letter.

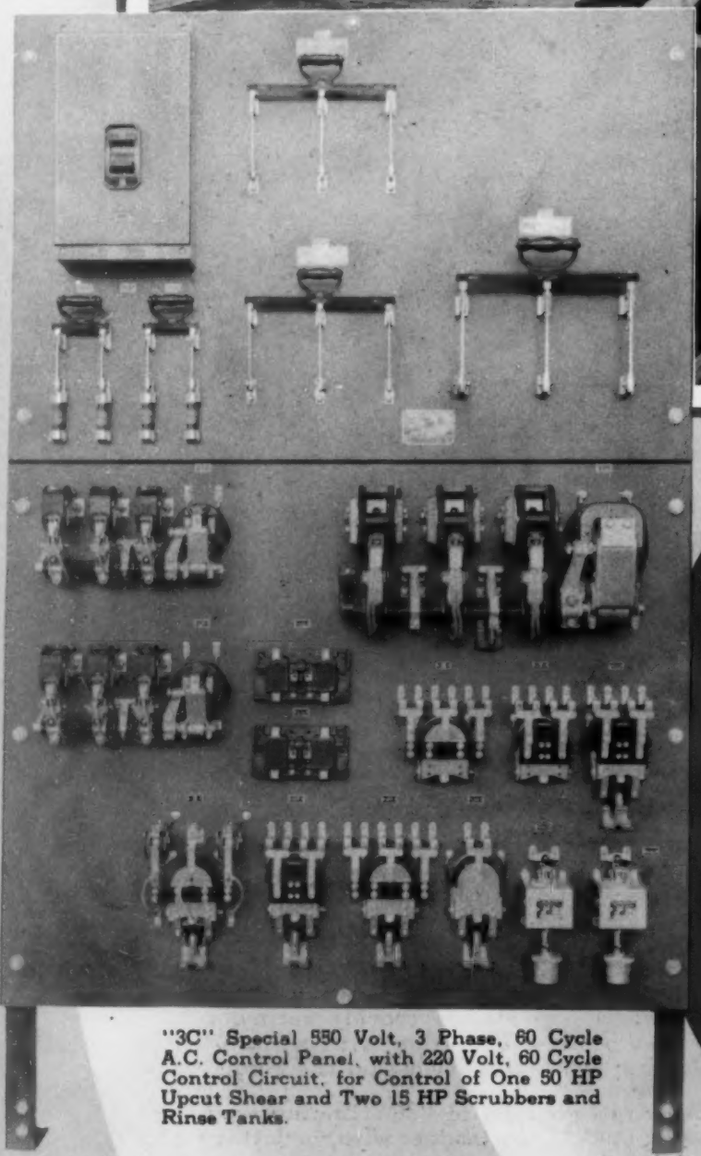
CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO

FOR EVERY AUXILIARY CONTINUOUS STRIP-MILL PROCESS, THERE'S A "3C" CONTROL

Continuous Strip Pickling Lines



"3C" Special 550 Volt, 3 Phase, 60 Cycle A.C. Control Panel, with 220 Volt, 60 Cycle Control Circuit, for Control of One 50 HP Upcut Shear and Two 15 HP Scrubbers and Rinse Tanks.

Pioneers in the Auxiliary Continuous Strip Mill Control Field, The Clark Controller Co. has kept constantly in step with each new development in Continuous Strip Mill operation.

"3C" Engineers never cease refining Electrical Control Apparatus to make it meet the exacting demands of high speed continuous operation.

Each year, new "3C" auxiliary devices, such as Cam Limit Switches, Heavy Duty Push Buttons, Hatchway Limit Switches, Foot Switches, Master Switches, Relays, and Resistors are developed—each contributing its part to successful low-maintenance Continuous Strip operation.

Our nearest office is as handy as your 'phone.

CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO

NEW COLT INDUSTRIAL MULTI-BREAKERS

Greater Efficiency . . . Safety

at Low Cost

Type M-1 15 to 50 Amperes

Type M-2 50 to 100 Amperes

230 Volts AC — 2 and 3 Poles

Industry has had the need for top-speed production and the continued strain of three-shift operation is placing great demands upon electrical equipment. Safe . . . automatic protection for lighting and power circuits is of prime importance . . . and the NEW Colt Industrial Multi-Breakers have been designed to meet these requirements. Adequate and reliable breaker performance at low initial and low maintenance costs.

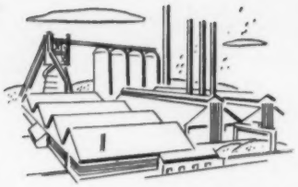
1. **Thermal trip provides time delay on momentary overloads. Magnetic trip assures instantaneous trip on heavy short circuits.**
2. **Tripped position indicated through small window in front cover.**
3. **Common trip breaker units eliminate single phasing.**
4. **Cover mechanism designed for quick-make and quick-break operation.**
5. **Semi dust-tight enclosures . . . surface type . . . front operation permits close banking.**

COLT ELECTRICAL PRODUCTS

MANUFACTURED BY A WORLD FAMOUS ORGANIZATION

COLT'S PATENT FIRE ARMS MFG. CO., HARTFORD, CONN.

ELECTRICAL DIVISION



Here's a *REAL* Yardstick for Control Performance!

...the Hagan job in the J&L Eliza works

THE five boilers in J&L's Eliza Furnace Department can produce a million and a half pounds of steam per hour. Automatically burning blast furnace gas, or any combination of gas and pulverized coal when gas fuel is scarce, they supply an unfailing steam supply for extremely fluctuating loads in the 96" strip mill. How they function is an engineer's dream.

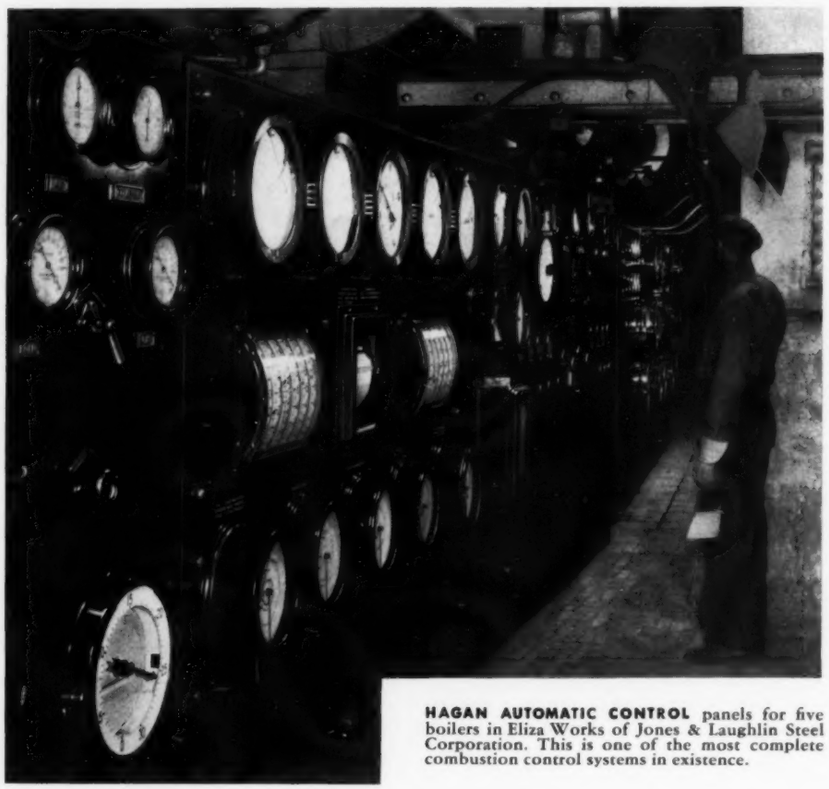
As each hot slab enters the rolls, the surging current, on the ammeter, nearly jolts the pen off the chart. In the load dispatcher's office, the recording wattmeter spins an uncanny story of instantaneous power load pick-ups of 20,000 to 25,000 kw.—and equally speedy cut-offs as the mills release their loads.

In the generating room, the turbine groans as it shoulders the violent load increases—and the steam-flow pen inks a wicked "sunburst" as it shifts with the load on a seesaw. But over near the boiler room the steam pressure chart shows maintenance of pressure at 410 lbs. *within one per cent!* Surely the boiler room gang must be working black magic to hold that pressure constant!

Along the firing aisle, on five gleaming panel boards, red and green lights flash on and off, silently signalling the *automatic* starting and stopping of powdered-coal burners, the opening and closing of dampers.

We pass one boiler and then another —not an operator is in sight. At the third boiler, one man calmly views the panel board while another man eats his lunch.

While the load is jumping all over the lot, Hagan Automatic Combustion Control is on the job, ably directing the complex system of fans, burners, dampers, boilers and turbines. Hagan Control maintains maximum fuel efficiency by correctly proportioning the fuel and air.



HAGAN AUTOMATIC CONTROL panels for five boilers in Eliza Works of Jones & Laughlin Steel Corporation. This is one of the most complete combustion control systems in existence.

It distributes the load evenly among the boilers, automatically regulates drafts and pressures *without human attention.* This is *fully automatic* Hagan Combustion Control at its best—the control system that thinks like an engineer and acts instantly!

WHAT CAN HAGAN DO FOR YOU?

Simply this. If standard Hagan equipment can handle the J & L-type loads—admittedly unusual—and maintain maximum efficiency *continuously,* that *same* standard Hagan equipment will do the best job you ever saw in your own plant —large or small—*without* pampering. All we ask is the chance to prove it.

HAGAN CONTROL JOBS IN J&L WORKS

Eliza . . . Combustion control for five boilers. Three pressure reducing and desuperheating systems. Full automatic control on slab-heating furnaces. Blast-furnace gas bleeder control.

South Side . . . Soaking pit control. Open-hearth furnace control.

Aliquippa . . . Combustion control for blooming-mill boilers. Combustion control for coke-plant boilers. Pressure reducing and desuperheating control.

Hazelwood . . . Combustion Control for coke-oven boilers.

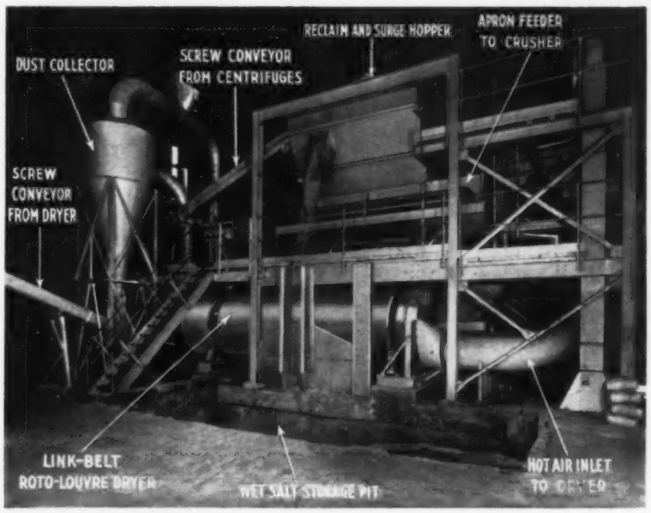
HAGAN CORPORATION · 300 ROSS STREET · PITTSBURGH, PA.

HAGAN *Automatic* COMBUSTION CONTROL

The pioneer . . . and still the leader

Serving Jones & Laughlin:

LINK-BELT CONVEYING • DRYING • EQUIPMENT



LINK-BELT ROTO-LOUVRE DRYER receives ammonium sulphate from centrifuges at approximately 2% moisture and dries it uniformly to less than 0.1% in a single pass; with minimum stack losses; minimum degradation of crystal size; at the rate of 5 tons per hour.

● Production and still more production is the crying need today. Delays cannot be tolerated.

Link-Belt equipment is widely used throughout the steel and other industries where its high efficiency and dependable performance are aiding in the battle for production. Put your problems up to experienced Link-Belt engineers.

LINK-BELT COMPANY

Chicago Indianapolis Philadelphia Atlanta Dallas San Francisco
Toronto Pittsburgh Cleveland Detroit
Other offices, warehouses and distributors in principal cities.

8638

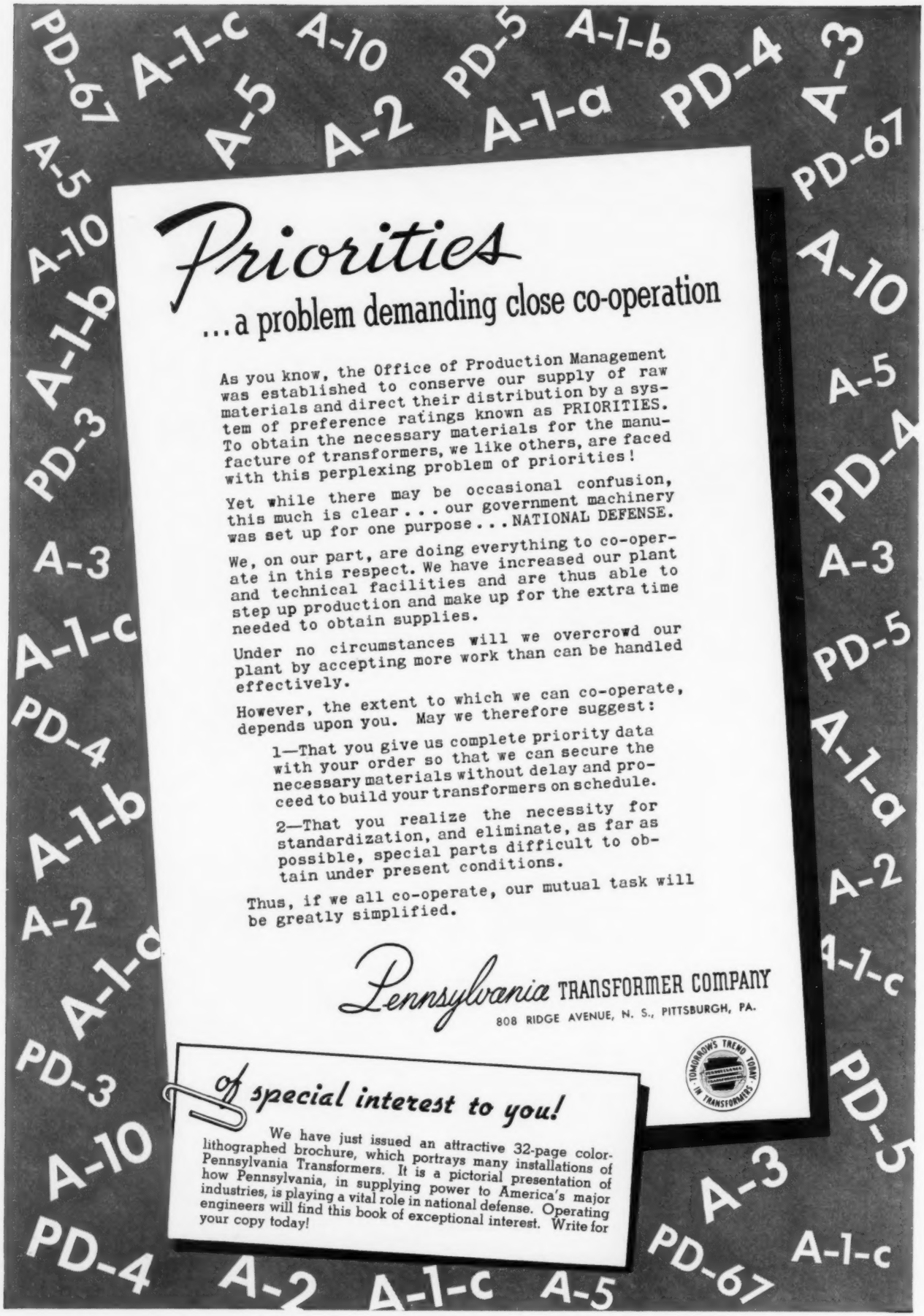
OVERHEAD CONVEYORS

Coils of rod are cooled, banded and inspected, as they are handled on Link-Belt conveyor from reels to storage building. This conveyor is equipped with mechanical loading and discharge mechanism.

COAL HANDLING Numerous Link-Belt coal handling installations are in service at J&L plants. The one pictured above is installed at their Pittsburgh By-Product Coke Plant to deliver coal to emergency ground storage from main handling system, or, supplemented by Link-Belt crane, to convey reclaimed coal from ground storage to overhead bunker from which it is fed to coal washer.

LINK-BELT BELT CONVEYORS Low maintenance and proved efficiency have been chief factors in the selection of Link-Belt anti-friction belt conveyor idlers for conveying coal and coke in the by-product plants at the Pittsburgh and Aliquippa Works.

See our Exhibit at the Iron and Steel Exposition, Cleveland, Ohio, September 23-24,25, Space 43.


PD-67 A-1-c A-10 PD-5 A-1-b A-3
A-5 A-5 A-2 A-1-a PD-4 PD-67
A-10 A-1-b PD-3 A-10
A-5 PD-4
A-3 A-3
A-1-c PD-5
PD-4 A-1-a
A-1-b A-2
A-2 A-1-c
A-1-c PD-3
PD-3 A-10
A-10 PD-4 A-2 A-1-c A-5 PD-67 A-3 A-1-c
Priorities
...a problem demanding close co-operation
As you know, the Office of Production Management was established to conserve our supply of raw materials and direct their distribution by a system of preference ratings known as PRIORITIES. To obtain the necessary materials for the manufacture of transformers, we like others, are faced with this perplexing problem of priorities!
Yet while there may be occasional confusion, this much is clear . . . our government machinery was set up for one purpose . . . NATIONAL DEFENSE.
We, on our part, are doing everything to co-operate in this respect. We have increased our plant and technical facilities and are thus able to step up production and make up for the extra time needed to obtain supplies.
Under no circumstances will we overcrowd our plant by accepting more work than can be handled effectively.
However, the extent to which we can co-operate, depends upon you. May we therefore suggest:
1—That you give us complete priority data with your order so that we can secure the necessary materials without delay and proceed to build your transformers on schedule.
2—That you realize the necessity for standardization, and eliminate, as far as possible, special parts difficult to obtain under present conditions.
Thus, if we all co-operate, our mutual task will be greatly simplified.
Pennsylvania TRANSFORMER COMPANY
808 RIDGE AVENUE, N. S., PITTSBURGH, PA.
TOMORROW'S TREND TODAY IN TRANSFORMERS
of special interest to you!
We have just issued an attractive 32-page color-lithographed brochure, which portrays many installations of Pennsylvania Transformers. It is a pictorial presentation of how Pennsylvania, in supplying power to America's major industries, is playing a vital role in national defense. Operating engineers will find this book of exceptional interest. Write for your copy today!

Neloy flame hardened industrial Gears and Track wheels

Note the discoloration on the flame-hardened surfaces of the gears shown above . . . An unretouched photograph.

You have at your command, when you do business with National-Erie, a wide range of gear cutting equipment for the production of spur, bevel, mitre, Sykes continuous Herringbone gears . . . The complete facilities of modern machine shops manned by expert machinists . . . Moreover, you have heat-treating facilities for fully quenched gears, which together with electric and open-hearth furnace foundry facilities, permit complete control of the manufacture of the materials you order . . . As you note above, a typical group of diversified industrial Neloy gears and crane track wheels for Neloy Flame Hardening treatments No. 10A and No. 10B . . . Make your source of supply for special steel castings and finished parts for your equipment, the National-Erie Corporation . . . Bulletins No. 5 and No. 6 are worth having on file for constant reference . . . They are yours for the asking.

NATIONAL-ERIE
CORPORATION
ERIE, PA., U.S.A.

Permits precision of application

● Precision in the application of "National" brushes to your equipment is made possible by the close degree of uniformity to which those characteristics affecting performance are held.

Careful analysis of raw materials, accurate compounding of mixes, close control of pressure, temperature and time in production processes, inspection at each stage of production, and determination of final characteristics and performance make "National" brushes outstanding in respect to uniformity.

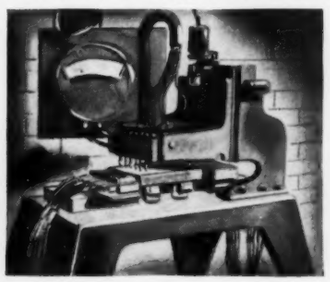
National Carbon Company engineers will recommend the grades adapted to your service.

SPECIFY NATIONAL BRUSHES
TRADE-MARK

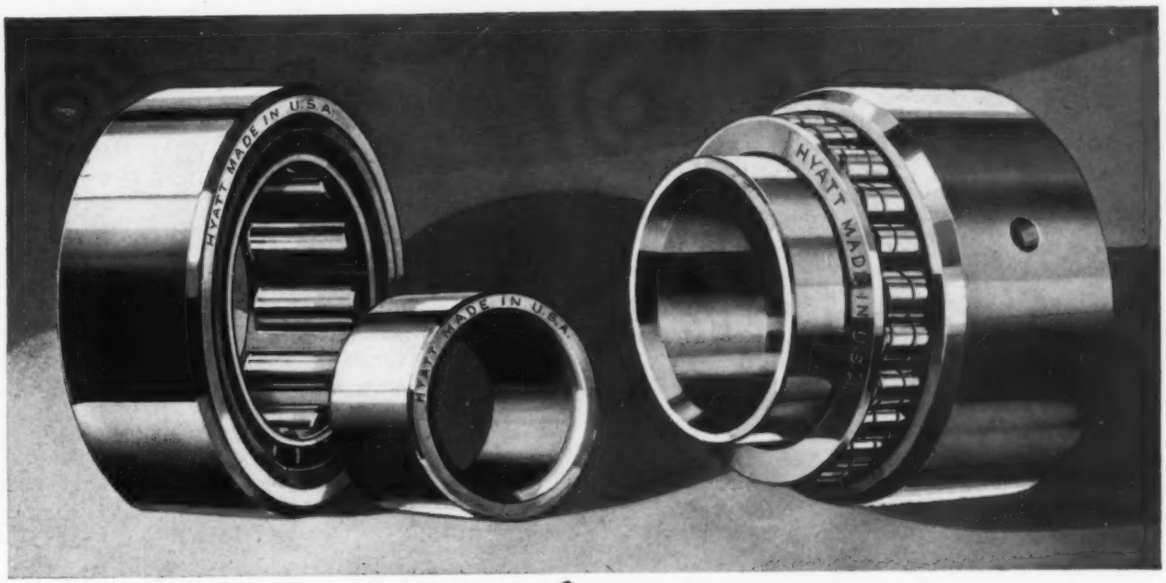
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation

UCC

Carbon Sales Division, Cleveland, O. General Offices: 30 E. 42nd St., New York, N.Y.
BRANCH SALES OFFICES: NEW YORK, PITTSBURGH, CHICAGO, ST. LOUIS, SAN FRANCISCO



KEEP THEM YOUNG WITH HYATTS



YOU ARE MORE INTERESTED in how Hyatt Roller Bearings perform than in the way they are built. Yet, the two go hand in hand. That's why we like to have you know how well we design and manufacture them and let their record of dependable performance tell the rest of the story.

At the IRON & STEEL EXPOSITION in Cleveland visit the Hyatt exhibit —spaces 24 and 25. Hyatt Bearings Division, General Motors Sales Corporation, Harrison, N. J., Chicago, Pittsburgh, Detroit and San Francisco.

HYATT

ROLLER BEARINGS

QUIET

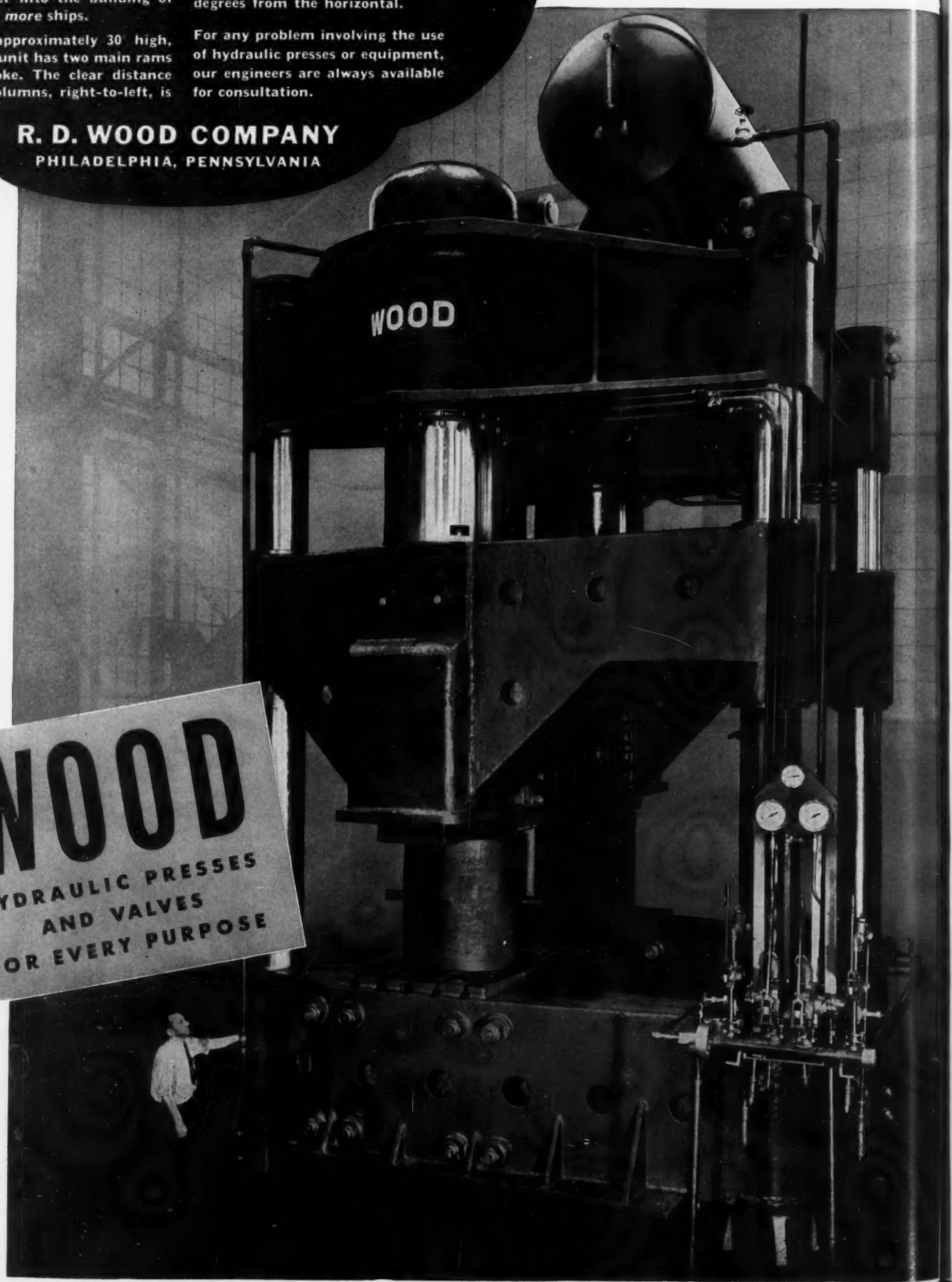
Shipbuilding...

This 1500 ton Wood plate bending and forming press performs a vital part in the numerous operations which enter into the building of ships—and *more* ships.

Standing approximately 30' high, this Wood unit has two main rams of 48" stroke. The clear distance between columns, right-to-left, is 9' 10" and front-to-back is 11' 10". The moving platen can be inclined, front-to-back, as much as 11½ degrees from the horizontal.

For any problem involving the use of hydraulic presses or equipment, our engineers are always available for consultation.

R. D. WOOD COMPANY
PHILADELPHIA, PENNSYLVANIA



WOOD
HYDRAULIC PRESSES
AND VALVES
FOR EVERY PURPOSE

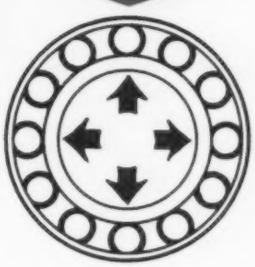
For CONTINUOUS OPERATION Under Capacity Load in Today's

168-hour week...

MCS
Double Width
Radial

Reduce Your Bearing Problems to Their SIMPLEST Components:

PURE RADIAL



PURE THRUST

MAXIMUM LOAD MINIMUM SPACE LONGER LIFE

Only a single load component—either pure radial or pure thrust—is carried on Rollway's massive rollers of hardened steel. This simplification of the load, plus the longer line contact and greater cross-section area of solid-cylindrical rollers, assures maximum load capacity in minimum space for a longer period of uninterrupted service.

Uninterrupted operation . . . 168 hours a week . . . every week! That's what today's emergency production calls for—the most gruelling test that friction surfaces are ever called upon to endure. That's why loads must be reduced to their simplest form. And that's why Rollway's pure-radial and pure-thrust roller bearings are so vitally important in today's machine design. Their solid cylindrical rollers carry heavier loads in limited space. They enable bearing "change over" for heavier continuous loads without redesign of the size relation of other parts. Submit your plans today for specialized bearing analysis and recommendations.

ROLLWAY

BEARING COMPANY, INC., SYRACUSE, N. Y.

SEE ROLLWAY EXHIBIT IRON AND STEEL EXPOSITION
BOOTHS No. 6 & No. 7 CLEVELAND PUBLIC AUDITORIUM

BEARINGS

here's how

to get more production

out of your machines

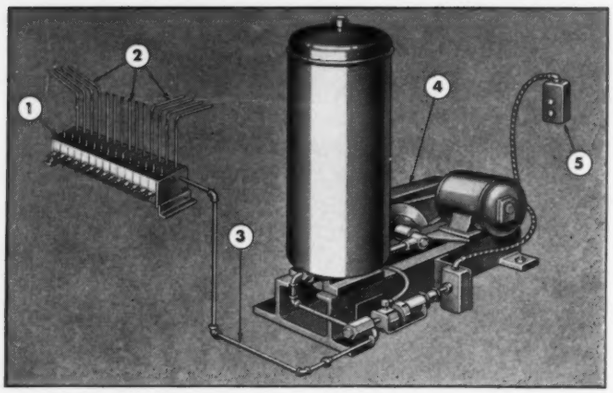
(Proper periodic lubrication will cut down bearing failures and increase the life of machinery*)

*LINCOLN

CENTRO-MATIC

LUBRICATING SYSTEMS

- Provide a means for periodically supplying a group of bearings with lubricant pumped from a central source, and accurately controlling the quantity of lubricant applied to each bearing.
- Only one lubricant supply line is required . . . Easy and inexpensive to install.
- Available for a wide range of applications . . . Electric, Compressed Air or manually operated.



Above is a diagrammatic illustration of a Semi-Automatic Push Button Controlled Centro-Matic System consisting of—
1—An injector for each bearing surface to be lubricated—mounted in manifold.
2—Suitable feeder lines to connect the injector outlets with the bearings.
3—A Single Lubricant Supply Line leading from the lubricant pump to the injectors.
4—An electric motor operated lubricant pump of 40-lb. capacity.
5—Push button switch conveniently located.

Act Now! Equip your machines with this modern method of lubrication

Let a Lincoln engineer recommend the Centro-Matic system best suited to your needs.

Lincoln Centro-Matic Systems can be installed on old machines already in operation, or can be installed on new machines.

The Lincoln Centro-Matic System consists primarily of a group of Centro-Matic Injectors—one for each bearing surface to be lubricated—and a suitable lubricant pump for supplying lubricant under pressure to the injectors. The operating principle is such that only a Single Lubricant Supply Line is required between the pump and the Centro-Matic injectors. Each injector is connected to a bearing surface by means of copper tubing or flexible hose as may be required.

Centro-Matic Systems have a wide range of applications ranging from Full-Automatic Power-Operated installations with time clock control to Semi-Automatic and Manually-Operated Systems; the lubricant pump may be either permanently installed to supply the injectors in a specific system, or it may be detachable and portable to permit supplying several systems in turn.

In addition to the Centro-Matic Systems, the Lincoln line of industrial lubricating equipment includes many types of hand-operated, electric and air operated grease guns, and a full range of all types and sizes of grease fittings. This line is *complete*—including all the equipment necessary for dispensing grease from the original container to the bearing, without the usual danger of contamination. . . . For details—write for Bulletin No. 888 and Catalog No. 61.

141-3

LINCOLN ENGINEERING COMPANY

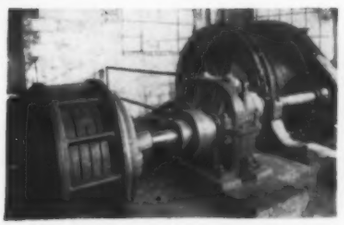
Pioneer Builders of Engineered Lubricating Equipment

ST. LOUIS, MO., U. S. A.

Jones HERRINGBONE SPEED REDUCERS

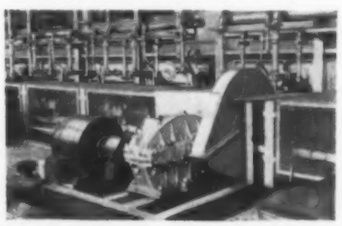
• This view of a Jones Triple Reduction Herringbone Speed Reducer typifies a line that is noted for advanced design, superior materials and precision workmanship.

• Catalog No. 70 of Jones Herringbone Reducers presents a vast amount of data relating to Herringbone Reduction Units. Illustrations show a broad range of herringbone reducer applications and technical information shows how to select reducers for all conditions of service in accordance with the A.G.M.A. recommended practice.



• Single type Jones Herringbone Speed Reducer driving hoist in coal mine.

• Double type Jones Herringbone Speed Reducer driving kiln in cement plant.



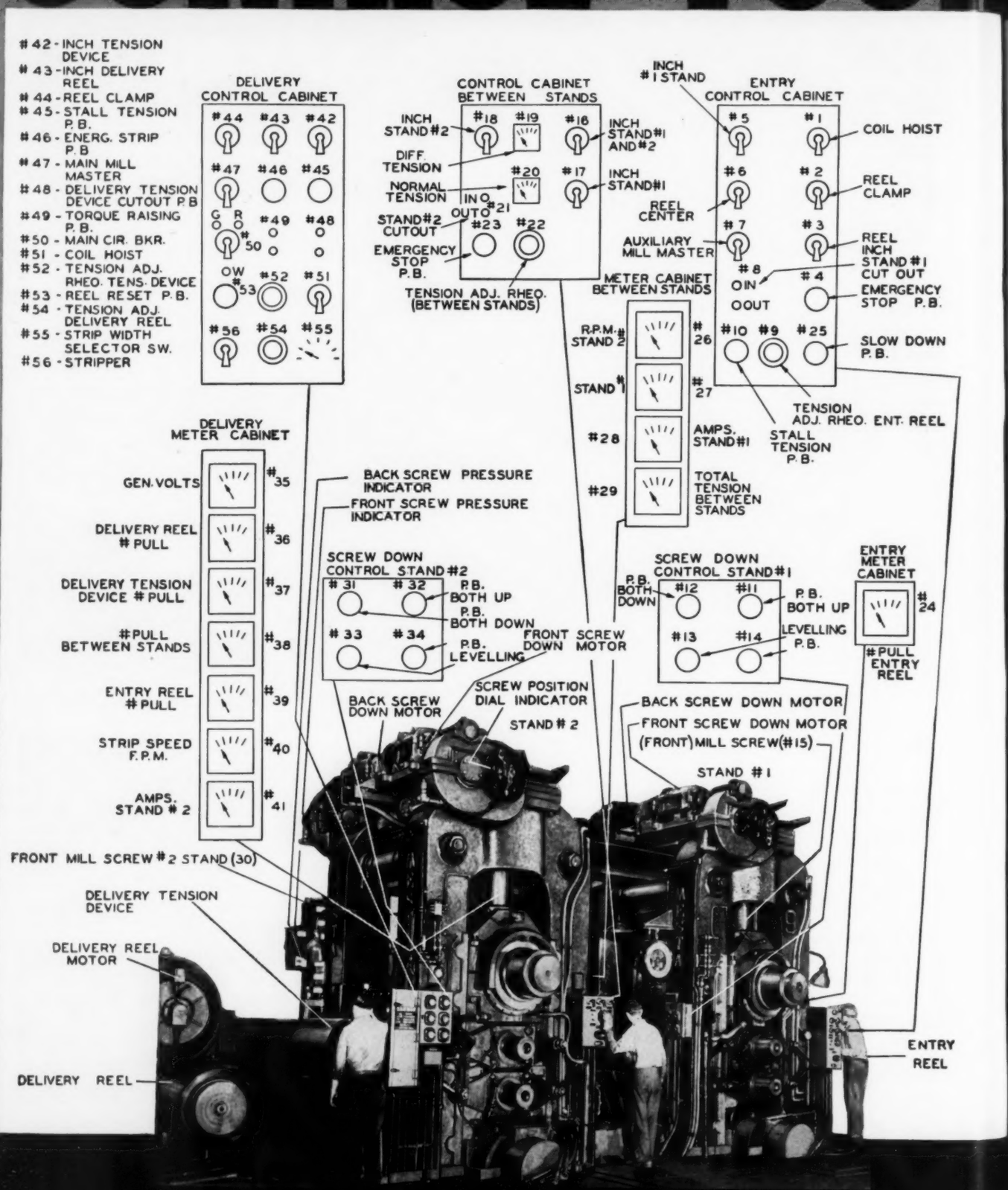
• Shown above is a triple type Jones Herringbone Speed Reducer driving normalizing furnace in steel plant.

JONES Herringbone Gear Speed Reducers are built in a wide range of ratios and ratings to cover every requirement. Single (Type SH) reducers in standard ratios range from 1.25 to 1 up to 11 to 1 in ratings from 1.3 to 440 H.P. Double (Type DH) reducers are built in standard ratios from 10.9 to 1 up to 72 to 1 in ratings from 0.5 to 275 H.P. The triple reduction reducers (Type TH) cover a range of ratios from 86.9 to 1 up to 355.8 to 1 in ratings from 0.3 to 78 H.P.

All these reducers have heat treated gears, ground shafts and are mounted with anti-friction bearings throughout. Cast Iron bases are available for all variations of motor assembly. Liberal stocks are carried to facilitate shipments.

W. A. JONES FOUNDRY & MACHINE CO.
4431 Roosevelt Road, Chicago, Illinois

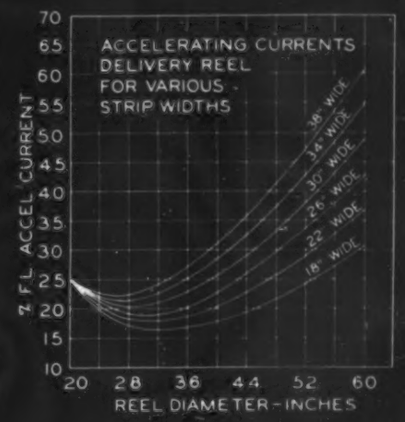
CONTROL YOUR



A 42 INCH, TWO-STAND TIN TEMPER MILL in a large eastern mill, showing control points for the new Allis-Chalmers tension control. The main drive and reel motors are also Allis-Chalmers-built.

TEMPER !

Eleven Temper Mills in 18 Months Equipped with Revolutionary New Allis-Chalmers Control. Read How You Can Cut Your Costs of Production ... Maintain Shipping Schedules ... by Eliminating Strip Breaking and Wrinkling!



AMOUNT OF POWER required to accelerate the reel and motor inertia to 2000 feet per minute in eight seconds.

SEPARATELY mounted electrical control for the 42 inch, two-stand tin temper mill.

With national defense orders already pushing the steel industry above 94% capacity, it is only natural that rolling mills built today must operate at higher speeds. And with this speeding up, the problem of strip breaking and wrinkling during starting and stopping becomes more acute.

To eliminate this cause of mill shutdowns . . . with consequent increased costs of production and delayed shipping schedules . . . the Allis-Chalmers control engineers several years ago began to develop a method of holding strip tension constant during acceleration and deceleration.

Eleven Mills in 18 Months!

We honestly believe these control engineers found what they were looking for. So, evidently, do mill operators all over the country . . . for during the past 18 months, eleven temper pass mills have been equipped with the new Allis-Chalmers automatic tension control. But here are the facts . . . you be the judge!

On the 42 inch, two-stand tin temper mill shown at left, a 16,000 pound coil must be accelerated to 2050 feet per minute in 12 seconds . . . a rate of 165 feet per minute per second. Compare this with the former acceleration of 75 feet per minute per second . . . consider that it takes four times the power to accelerate a given flywheel to twice the speed in the same period of time . . . and you can see that it's a real tribute to the ability of the Allis-Chalmers control engineers when the operators of this mill swear by its performance under all operating conditions.

Remember, too, that acceleration varies as the coil builds up on the delivery reel and is also dependent on strip width. (See curve above.) By merely setting a selector switch (No. 55), your operator can adjust the inertia compensation for any strip width, and the tension is automatically maintained constant.

Equally important, heavy-duty Allis-Chalmers Lo-Maintenance Motors and motor-generator sets are tailor-made to keep your production rolling. Full measure construction . . . with no skimping on materials . . . gives you a motor with more than just a rated horsepower.

If you have a problem in your mill that calls for specialized engineering, call the district office near you. Or write direct to Allis-Chalmers, Milwaukee. A-1322

Over 90 Years of Engineering Superiority Work for You When You Specify Allis-Chalmers!

ALLIS-CHALMERS

MILWAUKEE · WISCONSIN

INSTRUMENTS ARE Bloodhounds THAT LEAD THE WAY TO INCREASED TONNAGE

★

ANY change in practice that will reduce the time, the fuel or the heat required for process operations, or will increase quality and thereby decrease rejects, will increase the tonnage of your mill.

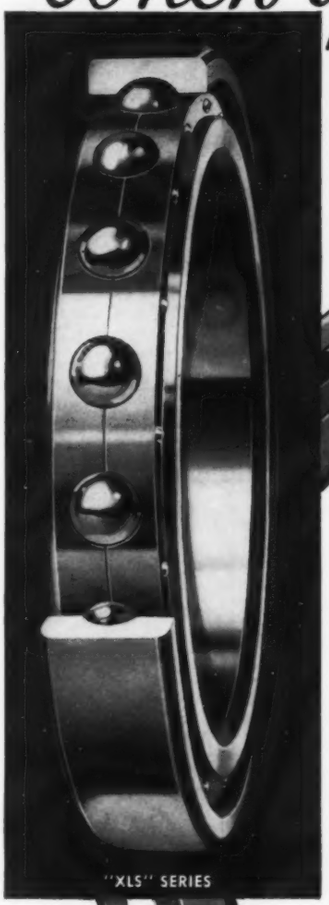
Instruments are the bloodhounds that lead the way to these economies in time and material. They serve as a guide to the operators in maintaining what has previously been determined, through the use of instruments, to be the most efficient practice. You can't improve conditions until you know what the conditions are. Instruments will give you the facts.

Republic engineers, men of wide experience in the metering and control problems encountered in steel mills, will gladly consult with your own engineers on any metering and control problem you may have. Ask today to have a Republic engineer call at your plant. Your request will involve no obligation on your part.

REPUBLIC FLOW METERS CO.
2220 Diversey Parkway, Chicago, Illinois

When You're Cramped for Space

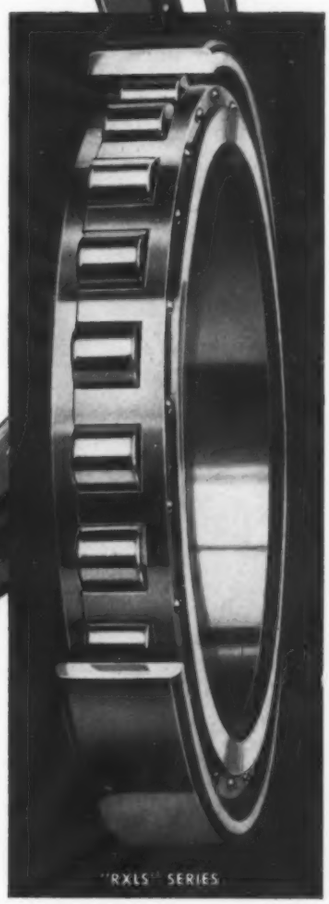
USE THESE VERY LIGHT INCH SERIES BEARINGS



HAVING bores abnormally large, as compared with the outside diameter, they offer definite advantages under certain conditions found in machine design. You may have them in several different types, *affording compactness, light weight, and greater latitude in your design.*

There are several lines of very light type ball bearings, which include the "S" starting at 1/8" bore, and the "XLS" starting at 1 3/8" bore, running up to a maximum of 21" bore and 28" outside diameter. And in very light type roller bearings, there is the "RXLS" Series, paralleling the "XLS" in size range.

Why not let our engineers tell you more about these Very Light Precision Bearings? Write for the Catalog.



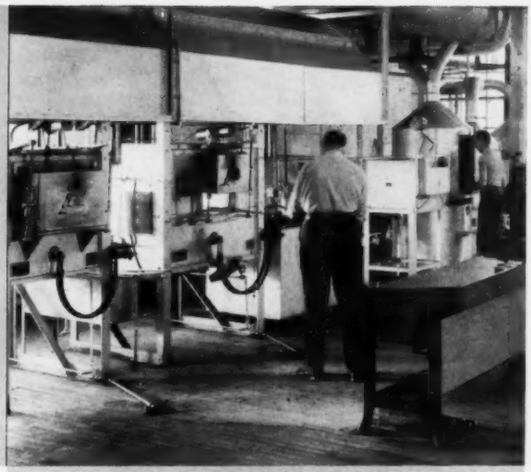
"NORMA-HOFFMANN"

PRECISION BALL, ROLLER AND THRUST BEARINGS

NORMA-HOFFMANN BEARINGS CORP'N.—STAMFORD, CONN., U. S. A.

For Better Products, Greater Production,

Use Electric Furnaces



Electric Furnaces used for hardening and tempering high-speed steel cutting tools at The Weldon Tool Company

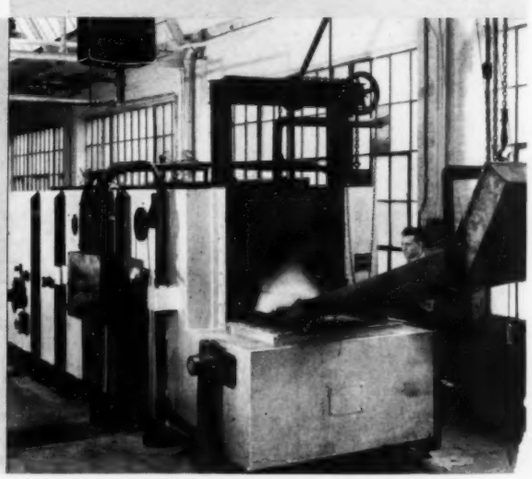
Electric Furnaces of many designs for many purposes are enabling numerous metal industries in the Cleveland district to make better products while achieving record-breaking production. On this page are pictured a variety of the many Electric Furnace installations in this district which have proved both their superiority and economy. As part of its service to industrial customers The Cleveland Electric Illuminating Company for many years has kept fully informed on developments in design of Electric Furnaces and their uses. Studies of customers' problems, with recommendations, are made free of charge or obligation. Simply call CHerry 4200 and ask for the Power Division,

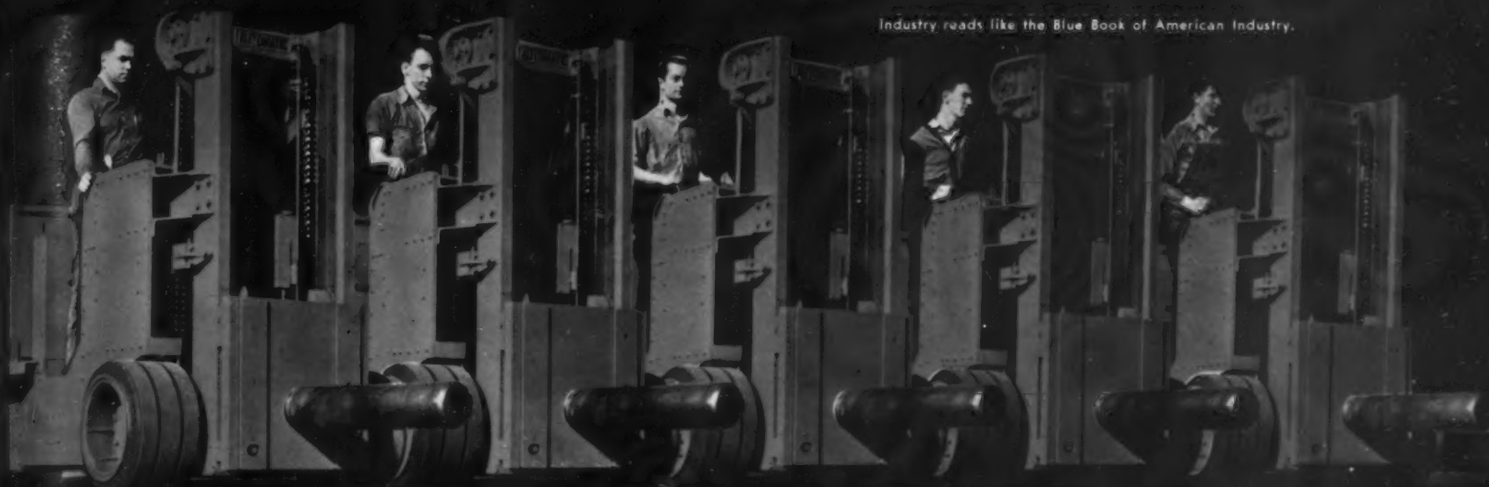
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Electric Salt Bath Furnace used for hardening parts of portable drills at The Chicago Pneumatic Tool Company

Electric Melting Furnace at The Ferro Machine & Foundry Company

Continuous Electric Furnace used for heat-treating screw products at The Cleveland Cap Screw Company

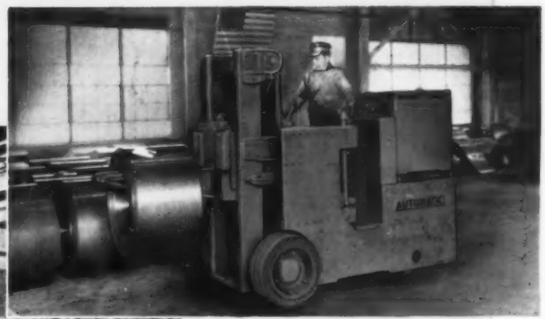




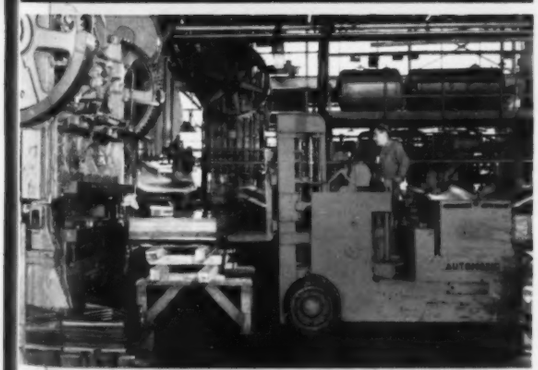
TRADE AUTOMATIC MARK

COIL TRACTORS SHEET HANDLERS

Fig. 10537-39. Heavy-Duty Telescopic Fork Trucks stacking 10,000-lb. bundles steel plate and placing at machine at height convenient to operator.



Coil Tractors — Capacities 8,000 to 18,000 lbs. Type illustrated 12,000-lb. capacity — fully equipped "AUTOMATIC" patented "Power-Steer" . . . Contactor Speed Control System . . . Heavy Duty Industrial Battery.



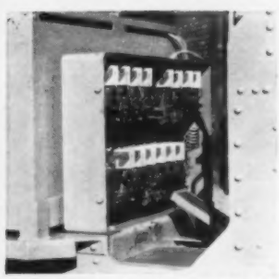


Fig. 10398. "AUTOMATIC" Magnetic Contactor Control System. Recommended and furnished on Heavy - Duty "AUTOMATICS." Provides smooth, safe, acceleration and deceleration by remote control.

Fig. 10171. Super-Service Center-Control "AUTOMATIC" Coil Tractor. Capacities, 20,000 to 30,000 lbs. Highly efficient for handling widest coils. Fully equipped "AUTOMATIC" Patented "Power Steer" . . . Contactor Speed Control System . . . ample space for maximum power supply.

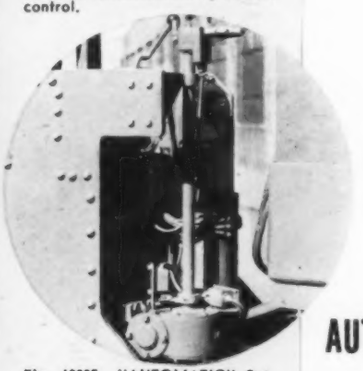


Fig. 10225. "AUTOMATIC" Patented "Power Steer" with Indicator Directional Control Handle shows position of wheels to operator when maneuvering. Recommended and furnished on Heavy-Duty "AUTOMATIC" Coil and Sheet Handlers.

MODERN PRODUCTION TOOLS CONTRIBUTING IMPORTANT ECONOMIES TO MODERN BUSINESS

● The "Electric Propelled" Coil Tractors, Sheet Handlers, Tractors and Cranes illustrated on this and next page are typical of the complete range of "AUTOMATICS" Time Proven Production Tools. These are offered to the Steel Industry to facilitate improved handling methods and modern low-cost co-ordinated coil and sheet handling systems regardless of load 2,000 or 30,000 lbs.

Hundreds of these "AUTOMATICS" shown here are today operating in many modern Steel Mills in United States, Canada and Foreign Countries. They are vital factors twenty-four hours, day in, day out, contributing successful, dependable, economical, profitable coil and sheet handling, transportation and stacking. Each of these "AUTOMATICS" reflect the ultimate in Modern Design—Sturdy Construction—Greater Capacity Facilities—Increased Efficiency — Dependable Performance — Flexibility with Precision and Safety.

REQUEST DETAILS AND LITERATURE

Perhaps one of these "AUTOMATICS" shown is just the type you need right now! Write or 'phone today for full details and prices without obligation.

AUTOMATIC TRANSPORTATION COMPANY
Div. of the Yale & Towne Mfg. Co.
141 W. 87th Street Chicago, Illinois

Listed Under Reexamination Service of UNDERWRITERS' LABORATORIES

WHEN YOU BUY TRUCKS - - Buy "AUTOMATIC"

TRADE **AUTOMATIC** MARK

MANUFACTURERS FOR OVER 30 YEARS

Electric Propelled INDUSTRIAL TRUCKS

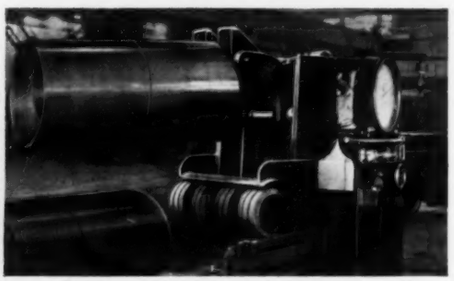
Fig. 10559. Unit load of steel plate being stacked by "AUTOMATIC" Center-Control Fork Truck. Capacities 3,000 to 8,000 lbs.

Fig. 10557. Fork Truck System co-ordinated with Tractor Trailer System from loading or unloading area to storage where hauls are long.

Fig. 10541. 10,000-lb. capacity High Lift Platform Truck facilitates general transportation and placing of bundled steel plate.

Fig. 10558. Fork Truck stacking bundled steel plate after removing from trailers shown above.

Fig. 9761. Tiering "Bosh Truck" provides highly efficient transportation and stacking system for Bosh Tanks. (Size tank illustrated, 42¾"x29"x32¾" high.

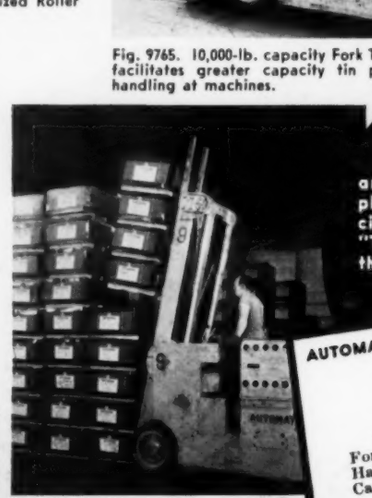


Super-Service Center-Control "AUTOMATIC" Coil Tractor. Capacities 25,000 and 30,000 lbs. Highly efficient for WIDEST WELDED Coils.

Fig. 9760. "AUTOMATIC" Heavy-Duty Low Lift Truck, 20,000-lb. capacity. Equipped with Motorized Roller Conveyor Platform.

Fig. 9765. 10,000-lb. capacity Fork Truck facilitates greater capacity tin plate handling at machines.

Fig. 10339 (left) — 9769 (right). Vertical multi-storage of finished products on Pallets. Saves storage space . . . eliminates needless rehandling . . . simplifies inventory process . . . reduces handling costs to minimum.



AUTOMATIC *Representatives* are listed in the classified telephone directories in principal cities and industrial areas under "TRUCKS, INDUSTRIAL" where this trade mark heading appears.

AUTOMATIC MATERIAL HANDLING EQUIPMENT

Electric— Gas-Electric **-AUTOMATIC-**

FOR EVERY PLANT TRANSPORTATION REQUIREMENT. Fork and Ram Trucks - Coil Handlers - Sheet Handlers - Low and High Lift Trucks - Load Carriers, Tractors, Cranes.

"WHERE TO BUY IT"

Heavy-Duty Tractors two and four wheel drive, capacities 3,500 to 6,000 lbs. Fully equipped with Contactor Speed Control.

"AUTOMATIC" LOW-LIFT TRUCKS

For heavy-duty top-performance and efficiency to handle 10,000-lb. skid loads. Standard platform 60" long, 26" wide, 11" high with 5" lift.

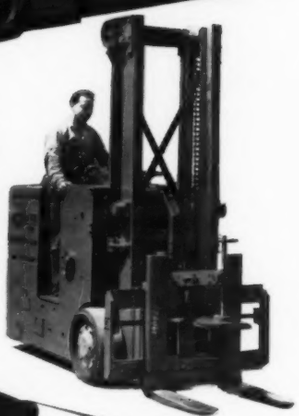


Fig. 9695. An ideal truck for diversified handling. Equipped with hand screw adjustable tinplate clamp. Forks are rubber backed and are quickly adjusted by hand screw device for pickup of Bosh tanks — pallet loads and bundled tinplate.

Fig. 9225. Combination Low Lift Truck 6,000-lb. capacity and hand slewing motorized crane, 2,000-lb. capacity. Ideal for general utility work and skid transportation.

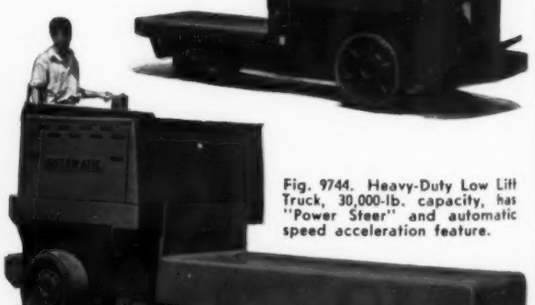


Fig. 9744. Heavy-Duty Low Lift Truck, 30,000-lb. capacity, has "Power Steer" and automatic speed acceleration feature.

DEPENDABLE MODERN HANDLING SYSTEMS FOR HEAVY DUTY STEEL MILL SERVICE CAPACITIES UP TO 30,000 LBS.

☆

- COIL AND FORK TRACTORS
- SHEET AND TIN PLATE HANDLERS
- BOSH TRUCKS
- LOW AND HIGH LIFT TRUCKS
- LOAD CARRIERS
- TRACTORS — CRANES

☆

AUTOMATIC TRANSPORTATION CO.

DIV. YALE & TOWNE MFG. CO.

141 W. 87th St., Chicago, Ill.

Printed in U. S. A.

WHEN YOU BUY TRUCKS . . Rust "AUTOMATIC"

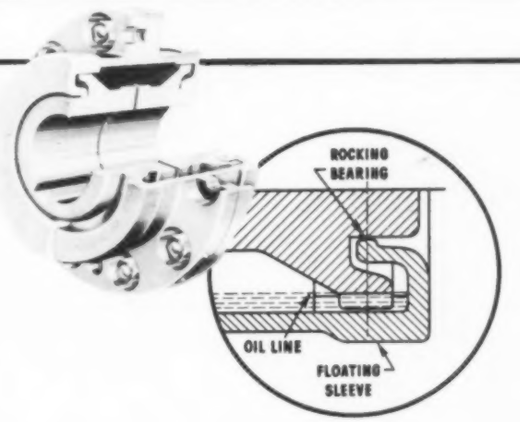
. . . and now that you're Maintenance Superintendent, you'll learn why I always insisted on FAST'S COUPLINGS

When promotions shift maintenance responsibilities to new shoulders, there's one sound tip that the "Old Head" often passes on to the new . . . "It will pay you to stick to Fast's Couplings."

The man personally responsible for continuous operation knows that his record depends on keeping dozens of pieces of complex equipment going. Couplings are vital links in the power-transmission chain. Practical operating men have learned, from many years experience, that they can depend on "Fast's" . . . and that the only economical coupling is the dependable one.

When you purchase new machinery—protect yourself against possible operating troubles, by specifying *genuine* Fast's Couplings.

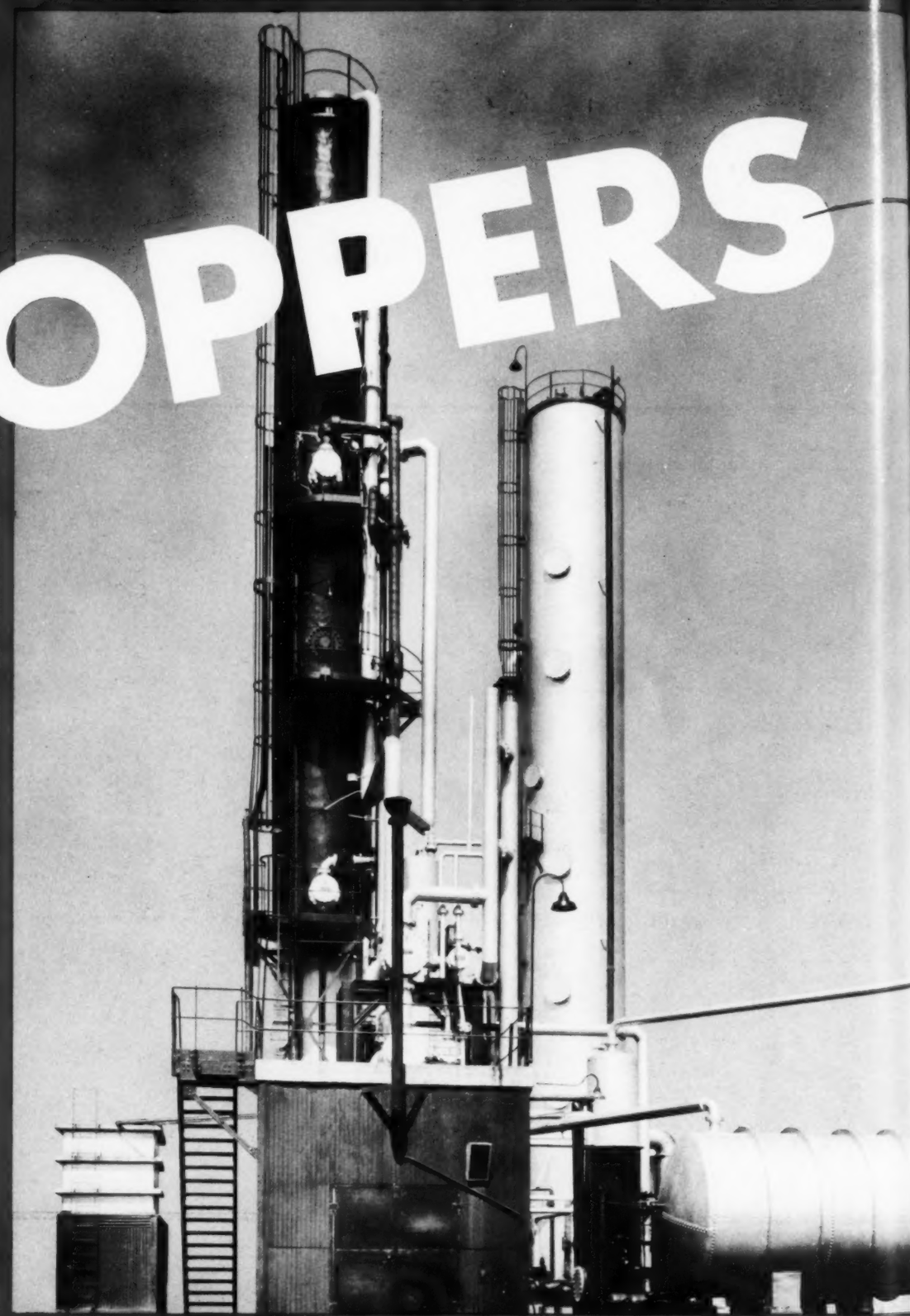
KOPPERS COMPANY
BARTLETT HAYWARD DIVISION
BALTIMORE, MD.



These cut-away and sectional views show Fast's exclusive design. The load carrying surfaces are protected against wear by a positive film of oil. This oil is kept permanently clean by rocking bearings which make precise metal-to-metal contact and are in the one position where they form permanent dust and moisture-proof seals. Only *genuine* Fast's Couplings have this feature.

a KOPPERS product

KOPPERS



This plant, at the Pittsburgh Coke and Iron Company, Neville Island, Pittsburgh, is the first ever built to recover hydrogen sulfide from coke oven gas for the purpose of manufacturing sulfuric acid.

The process is extremely simple. It uses a solution of sodium carbonate to remove the sulfur from the gas in the absorber shown above. This solution is regenerated by boiling under vacuum in the insulated column.

It treats 22,000,000 cubic feet of gas per day and produces approximately seven tons of H_2S per day, which will make 20 tons of 66° sulfuric acid.

ANNOUNCES

A NEW BY-PRODUCT DEVELOPMENT FOR THE STEEL INDUSTRY

Hot Actification Sulfur Recovery Process

The average steel mill coke plant has sufficient hydrogen sulfide available in its coke oven gas to provide ample acid for the production of ammonium sulfate and for the washing of light oils. In some cases, the H_2S is present in sufficient concentration to provide acid also for pickling operations in the steel mill.

Hydrogen sulfide can now be recovered at low cost by the Koppers Hot Actification Sulfur Recovery Process. The H_2S is in a form readily convertible into sulfuric acid by the conventional contact or chamber process.

In addition to the return from sulfuric acid production, there is a substantial credit due this operation for supplying desulfurized coke oven gas to open hearth and heat treating processes.

Where it is necessary to use high sulfur coal, the sulfur in the coal becomes a cheap raw material instead of a nuisance in the coke oven gas. The possibility of scarcity and rising prices for sulfuric acid makes this process even more attractive.

Koppers will be glad to give you figures on this process for your plant.

KOPPERS COMPANY

Engineering and Construction Division

PITTSBURGH, PA.

Koppers has developed a large number of technical folders on its products and services. Send this coupon for any in which you are interested:

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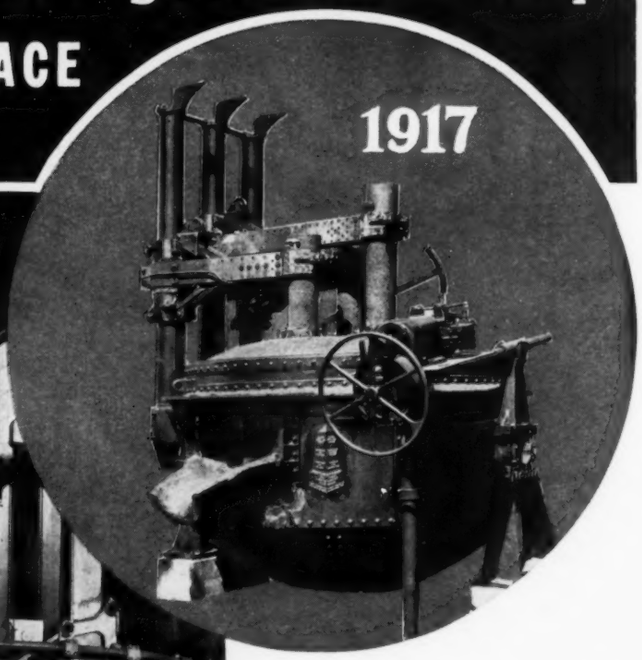
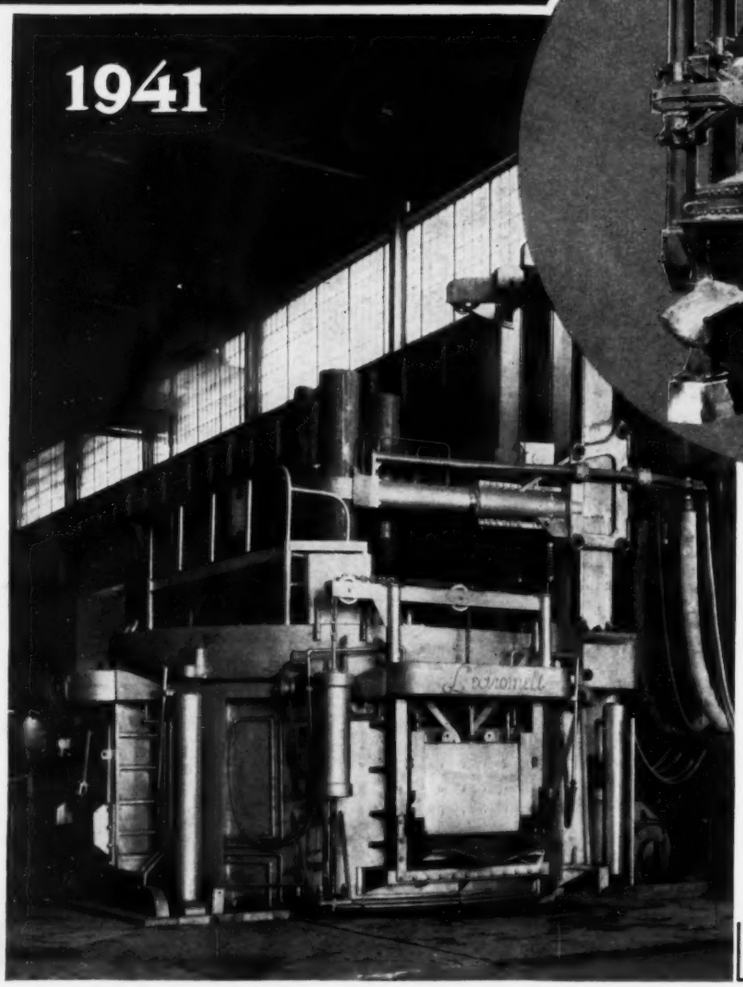
the KOPPERS *products*

25 years experience goes into every Lectromelt FURNACE





Pictured at left is the largest top charge electric furnace in the United States. This 50-ton Moore Rapid LECTROMELT furnace is in operation at the Copperweld Steel Company, Warren, Ohio and represents the most advanced construction in the electric furnace field.

Illustrated above is one of the first Moore Rapid LECTROMELT furnaces manufactured by this Company in 1917. It was operated for 15 years, melting 111,436 tons and was replaced by a top charge LECTROMELT. When installed it was the last word but it is now a relic and a monument to progress.

LECTRO LECTROMELTLECTROMELTLE

Because we are celebrating our 25th anniversary we feel that we can not take better stock of ourselves than by comparing the earliest and the latest LECTROMELTS. In other centuries a span of 25 years would see little change; in this century 25 years frequently means the difference between obsolescence and modernity. Moore Rapid LECTROMELT furnaces, both top charge and door charge types are built in standard sizes ranging from 100 tons down to 25 lbs. capacity. The experience we have gained in 25 years serves us well because it enables us to serve efficiently all who melt and produce steel, iron, ferro-alloys, calcium carbide, etc. Write us for details on LECTROMELT equipment to meet your requirements.

PITTSBURGH LECTROMELT FURNACE CORPORATION

PITTSBURGH, PENNSYLVANIA

Today....PENOLA meets a new kind of PRESSURE!

It's the pressure of a huge backlog of orders—the demand for faster and faster production as America arms.

Never before has it been so important to avoid breakdowns—to keep all mills running at top capacity. And schedules like these call for the protection that Penola lubricants can give. They're tough and clingy—designed to prevent the costly metal-on-metal contact that scores rollers and burns out bearings.

Today, in most of America's 4-high mills, Penola is on the job to keep things rolling. It's a fact—more Penola steel mill roller bearing greases are produced and sold than any other make in the world. Why not let Penola's engineers help solve *your* problems?

LUBRICANTS FOR THE STEEL INDUSTRY SINCE 1885

PENOLA
LUBRICANTS

PENOLA INC., PITTSBURGH, PA.
(FORMERLY PENNSYLVANIA LUBRICATING CO.) NEW YORK
CHICAGO · DETROIT · ST. LOUIS

BROSIUS EQUIPMENT

Speeds

PRODUCTION

On this page we show various types and capacities of Brosius Auto Floor Machines, arranged to handle charging boxes for charging melting furnaces; equipped with tongs for serving heating furnaces, mills, hammers, presses, etc.; and designed as manipulators for manipulating pieces under hammers, and presses, as well as charging and drawing the heating furnaces.

Brosius Auto Floor Chargers and Manipulators are self contained. They require no tracks or expensive runways and their movement is not restricted to any definite path. No provision, aside from a good floor on which to operate, is necessary for their installation.

The charging machines are driven by an electric motor, while the rotation and tilting of the peel or operation of the tongs are accomplished through oil cylinders operated by a motor driven oil pump mounted on the machine.

The Manipulators have six different motions and, with the exception of the travel motion, all are hydraulically actuated. The front and rear of the peel are raised and lowered by independent cylinders, so that the peel can at all times be kept level with the anvil dies.

All machines, both chargers and manipulators, are rubber tired, provided with anti-friction bearings and are hydraulically steered, eliminating all fatiguing effort on the part of the operator.

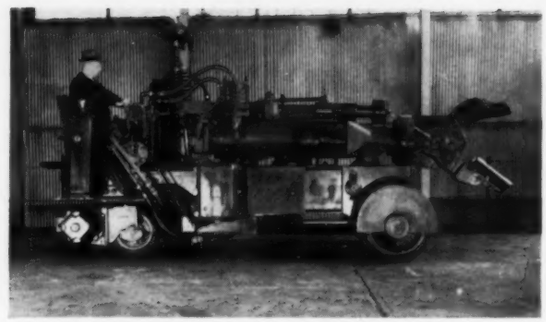
Electric power is received through a flexible cable and a rotating collector mounted on the mast of the machine, or gasoline motor generator set can be furnished.

With these machines extreme mobility is obtained as the tractor unit turns 180°, permitting the machine to turn on its own wheel base—a feature of great importance where operating space is limited.

Built in capacities of from 2000 lb. to 20,000 lb., we can offer a machine to meet most any charging or manipulating problem.

More than 100 Brosius Auto Floor Charging Machines and Manipulators are in operation in the United States and Abroad.

Send us your problems. We will be glad to work with you in solving them.



Above: This is our 6000 lb. capacity, Auto Floor Manipulator, used in handling billets under the steam hammer and press after charging and drawing the heating furnace.

Below: The 15,000 lb. capacity Auto Floor Tongs Charger, charges and draws from heating furnaces.

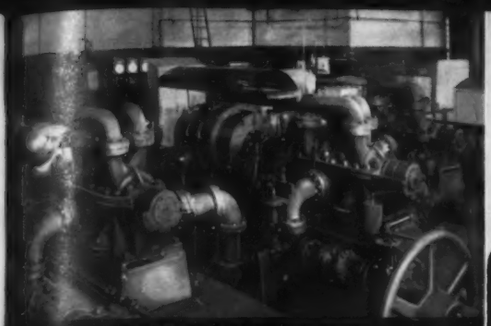
Above: A Standard 2000 lb. capacity Auto Floor Tongs Charger used in serving heating furnace and mill—charging and drawing slabs. *Below:* The Standard 4000 lb. capacity Auto Floor Box Charger, serves two thirty-five ton open hearth furnaces and handles five foot charging boxes, completing cycle in 45 seconds.

Edgar E. BROSIUS *Inc.*

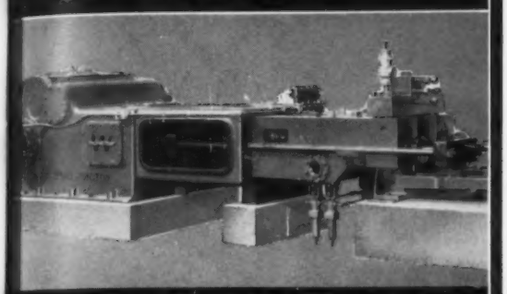
MANUFACTURERS & DESIGNERS OF SPECIAL EQUIPMENT
FOR BLAST FURNACES AND STEEL MILLS

PITTSBURGH SHARPSBURG BRANCH, **PA.**

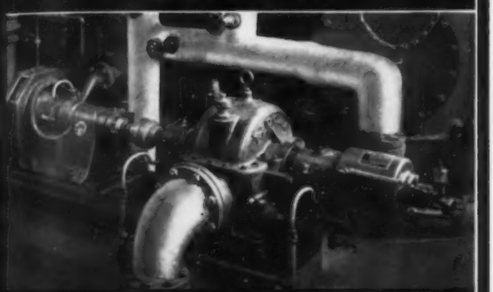
Brosius Equipment is covered by patents allowed and pending in the United States and Foreign Countries



Centrifugal high-pressure pumps for descaling service

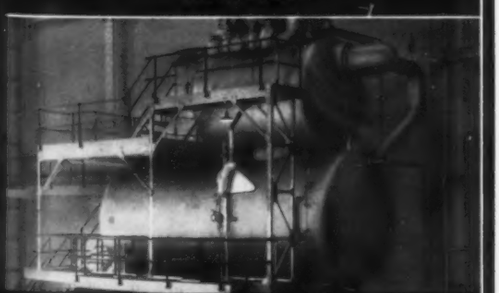


High-pressure power pump with synchronized suction valve unloader

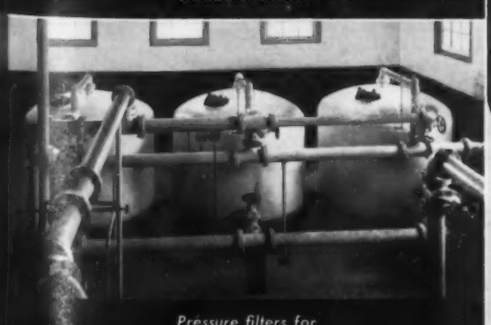


Worthite centrifugal pump, driven by Worthington-Moore steam turbine

Rotary pumps, for non-abrasive viscous liquids



Open type deaerating feedwater heater



Pressure filters for water purification

WORTHINGTON

Helping to BOOST STEEL PRODUCTION

ON the defense front, Worthington is equipping Army, Navy, Air and Maritime units. And behind the lines, in every American steel mill, Worthington equipment is performing vital services in meeting the demands for increased production. Additional Worthington units await installation as soon as enlarged mills are ready.

●

FOR CONTINUOUS STRIP MILLS

Complete descaling systems from pump to spray nozzle.

FOR DRY BLAST SYSTEMS

Dehumidification equipment . . . including centrifugal and reciprocating refrigeration compressors.

FOR BY-PRODUCT COKE PLANTS

General hydraulic service and water supply...pumps of every size and type, centrifugal, steam and power.

FOR THE POWER PLANT

Steam turbines, steam condensers, boiler feed pumps, feedwater heaters, air ejectors, vacuum pumps, water softeners and pressure filters.

FOR GENERAL AND LOCAL COMPRESSED AIR SUPPLY

Compressors of every type from the smallest to the largest . . . for every type of drive.

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Worthington engineers know steel mill requirements. They can give you real help in planning for expanded steel production.

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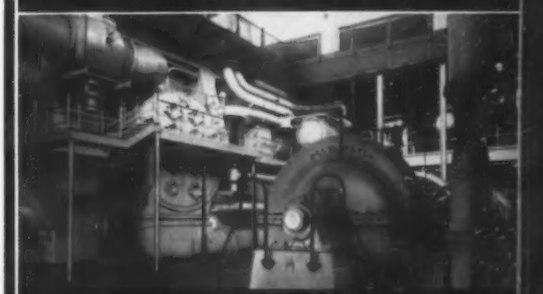
Centrifugal refrigeration compressors for dry blast dehumidification systems

Horizontal duplex compressors for large air requirements

Worthington-Moore steam turbine generating unit



Surface condenser and all auxiliary equipment

Centrifugal high-pressure six-stage boiler feed pumps

Centrifugal pumps for general water supply service

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"LARGEST BUILDERS OF THE WORLD'S LARGEST CRANES"

20 Ton 86'-0" Span Low Type Soaking Pit Crane

Alliance 2 Ton Pit Crane

The Alliance Machine Company designs and builds—

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OPEN HEARTH CHARGING MACHINES
SLAB & BILLET CHARGING and DRAWING MACHINES
CAR DUMPERS
FORGING MANIPULATORS
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ROLLING MILL MACHINERY and SPECIAL MACHINERY—*all to your individual requirements.*

THE ALLIANCE MACHINE COMPANY

ALLIANCE . . . . OHIO

MODERN STEEL MILLS *cash in on* R&IE *Experience*

Above—Support for double 10 inch channel bus.

Below—5000 Ampere Hi-Pressure Contact (Hinge and Jaw) Disconnecting switch.

It's one thing to be modern—

it's another to set the pace. Today, and for years to come, R & I E designers and craftsmen know the problems of the industry through continual research and application of proven methods.

It's good business to cash in on R & I E experience with Steel Mill Conductor Supports and Heavy Duty Disconnecting Switches. Their satisfactory performance in many important mills is evidence of their inherent stamina and trustworthiness.

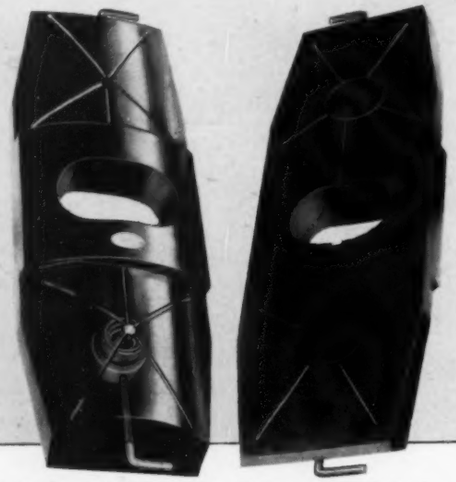
RAILWAY and INDUSTRIAL ENGINEERING COMPANY

Greensburg, Pa...Sales Offices in Principal Cities

MORE AND MORE ___ GATKE BEARINGS!

GATKE Fabric Bearings are engineered for the application and moulded to finished dimensions in special moulds that apply tremendous pressures in the direction that pressures are applied in service.

Even the self-lubricated low-friction Fabrics are a patented GATKE Development manufactured exclusively in GATKE Textile Plants. (Illustration shows a GATKE Bearing for 30" roll neck).



GATKE Self-Alyn Fabric Slippers extend the long wear life and great maintenance economies for which GATKE Fabric Slippers have long been noted. Moulded to finished dimensions (no machining required) for all types and sizes of Universal Couplings.

Another large GATKE Factory Unit, just completed, and tremendously increased moulding facilities, put GATKE in an exceptional position to meet the bearing requirements of Rolling Mills, despite unprecedented demands.

Users are further protected by the complete manufacture of GATKE Fabric Bearings in GATKE Factories. We are not dependent on outside fabricators.

GATKE Factories are centrally located in Rolling Mill areas, making possible close contact and permitting overnight delivery of shipments to all mills.

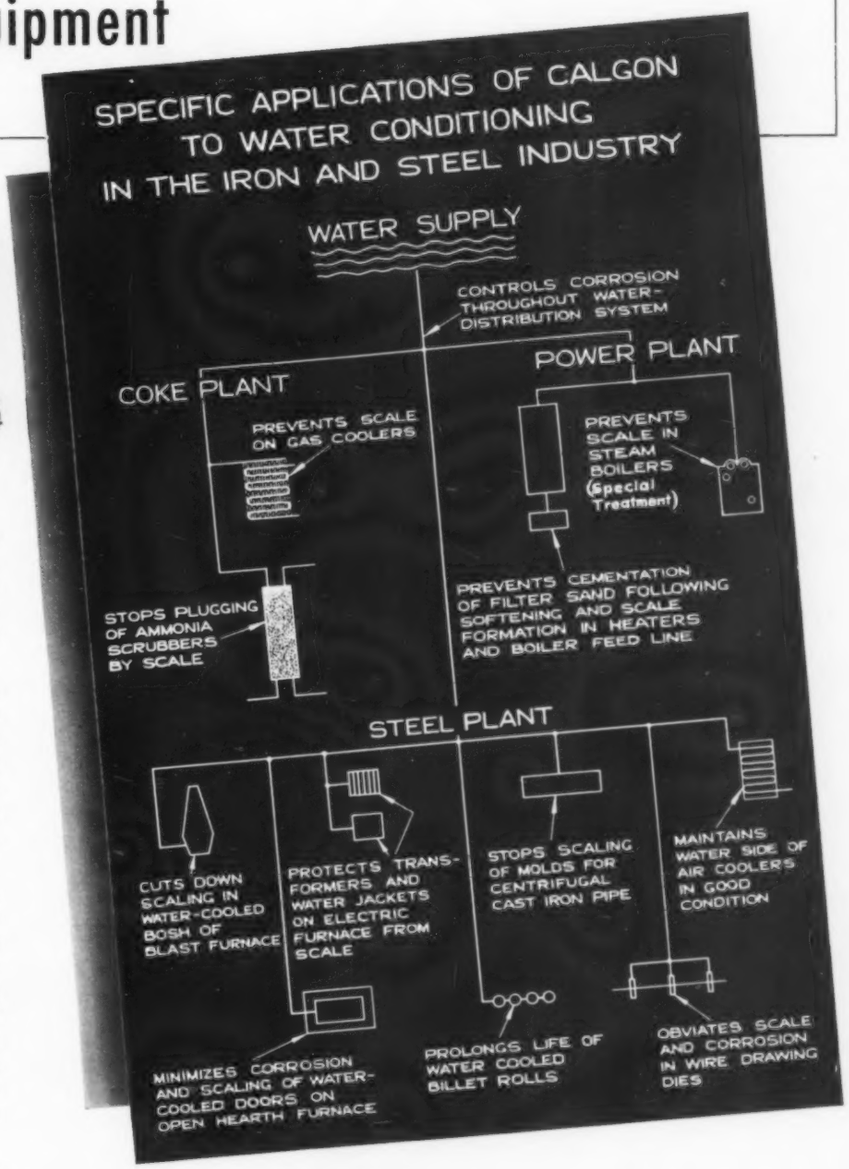
It pays to anticipate your bearing requirements to avoid emergencies . . . but if you are caught short, just tell us what you need.

GATKE CORPORATION
228 N. La Salle St. Chicago, Ill.

Gatke MOULDED FABRIC Bearings

For Roll Necks - Universal Couplings - Spindle Carriers - Housing Rolls - Cranes - Pickling Tanks - And Other Tough Service

New way to control Corrosion and Scale in water-cooled steel mill equipment


SPECIFIC APPLICATIONS OF CALGON TO WATER CONDITIONING IN THE IRON AND STEEL INDUSTRY
WATER SUPPLY
CONTROLS CORROSION THROUGHOUT WATER-DISTRIBUTION SYSTEM
COKE PLANT
PREVENTS SCALE ON GAS COOLERS
STOPS PLUGGING OF AMMONIA SCRUBBERS BY SCALE
POWER PLANT
PREVENTS SCALE IN STEAM BOILERS (Special Treatment)
PREVENTS CEMENTATION OF FILTER SAND FOLLOWING SOFTENING AND SCALE FORMATION IN HEATERS AND BOILER FEED LINE
STEEL PLANT
CUTS DOWN SCALING IN WATER-COOLED BOSH OF BLAST FURNACE
PROTECTS TRANSFORMERS AND WATER JACKETS ON ELECTRIC FURNACE FROM SCALE
STOPS SCALING OF MOLDS FOR CENTRIFUGAL CAST IRON PIPE
MAINTAINS WATER SIDE OF AIR COOLERS IN GOOD CONDITION
MINIMIZES CORROSION AND SCALING OF WATER-COOLED DOORS ON OPEN HEARTH FURNACE
PROLONGS LIFE OF WATER COOLED BILLET ROLLS
OBVIATES SCALE AND CORROSION IN WIRE DRAWING DIES

THE water-cooled jackets of blast furnaces, Bessemer converters, electric furnaces, open-hearth furnace doors and frames are subject to severe scale formation or corrosion or both, depending upon the type of water used for cooling.

Now, you can eliminate both troubles with a simple, low-cost water treatment using only a few parts of Calgon* per million of water. Calgon prevents the formation of calcium carbonate scale and gradually disintegrates old scale. It also reduces corrosion to such an extent that it ceases to be a serious problem.

A steel mill in western Ohio had serious difficulty due to failure of open-hearth furnace doors and frames. Scale formed on the doors, cracked off, accumulated on the bottom. This interfered with circulation, causing the doors to overheat and fail. Analysis of the scale showed it to be largely calcium carbonate and iron oxide. Since using Calgon Treatment, calcium carbonate scale has been prevented, circulation is maintained and the doors stay cool.

Calgon Treatment is also used to protect transformers and water jackets on electric furnaces from scale; it prolongs the life of water-cooled billet rolls, maintains water side of air coolers in good condition.

In the coke plant, Calgon-treated water prevents scale in gas coolers and reduces plugging of ammonia scrubbers by scale.

No elaborate or costly machinery is needed to start the Calgon Treatment — merely a simple feeding mechanism to get Calgon into the water.

Don't put up with costly, frequent cleaning and repairs. Send in the coupon and we'll give you all the technical information about Calgon that you need.

**Calgon is the registered trade-mark of Calgon, Inc. for its glassy sodium phosphate products.*

calgon, inc.
300 ROSS ST. PITTSBURGH, PA.

MAIL FOR COMPLETE INFORMATION

Calgon, Inc.
300 Ross St., Pittsburgh, Pa.

Gentlemen:
Send technical data on Calgon for preventing scale in cooling systems.

*Name*_____

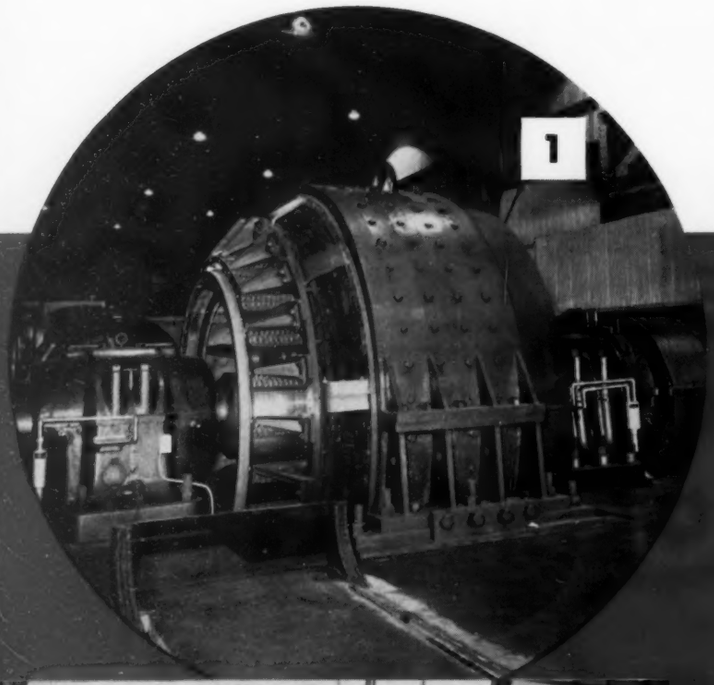
Company _____

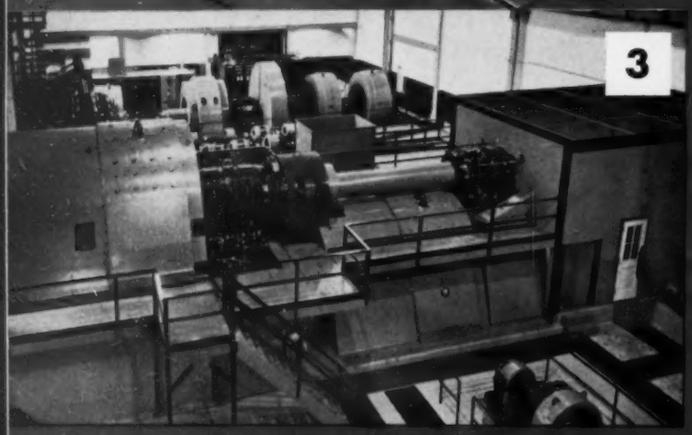
*Address*_____

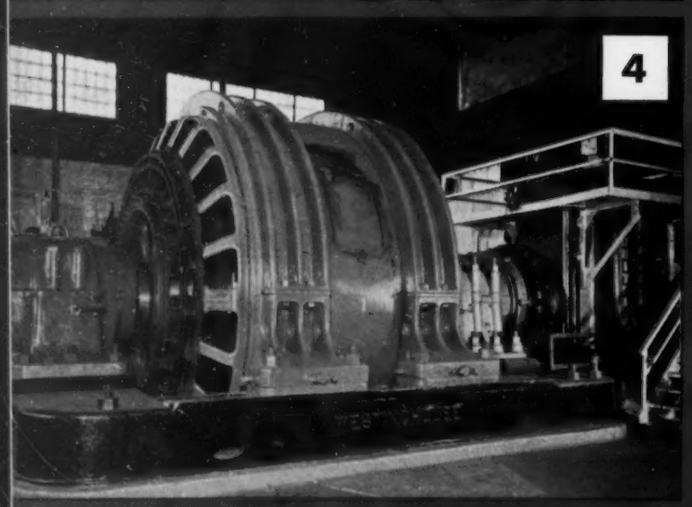
*City*_____ *State*_____

WESTINGHOUSE IS READY TO HELP PRODUCE

More







1. 7,000 hp Blooming Mill motor drive.
2. Twin motor drive totaling 10,000 hp driving the horizontal rolls of a Universal Slabbing Mill in the Pittsburgh District.
3. These two 5,000 hp motors form a twin drive for a Universal Slabbing Mill.
4. 8,000 hp 50/120 rpm motor driving a 46" Blooming Mill.
5. 4,500 hp slip ring induction motor driving the Spreading Stand of a Universal Plate Mill.

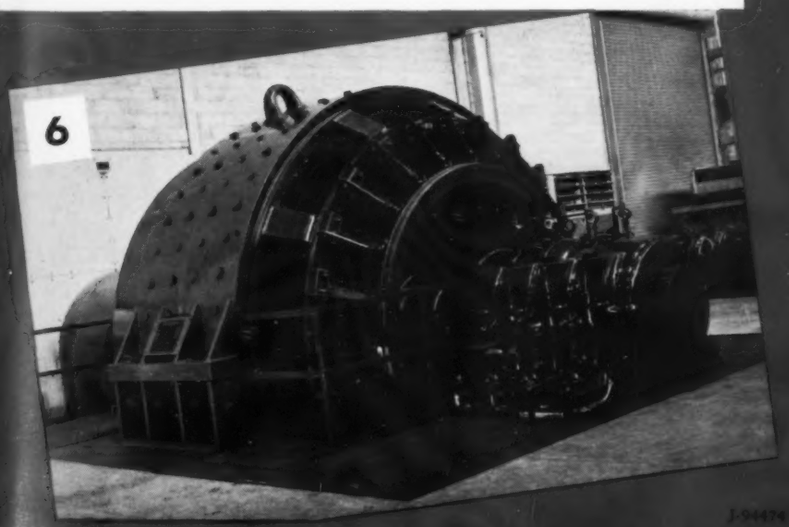
WESTINGHOUSE

Westinghouse

Steel

More steel for Defense—will require more rolling capacity—more Blooming, Slabbing and Plate Mills. Westinghouse is ready to meet this demand. Ready—by virtue of our background of experience as leading suppliers of heavy main drive equipment. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

6. This 7,000 hp motor drives the Reversing Roughing Stand of a Universal Plate Mill.
7. 4,000 hp reversing plate mill drive in a Southern Steel Mill.
8. The main and edger drives for a Slabbing Mill in the Middle West. These three motors have a total horsepower of 12,500.
9. This 7,000 hp motor drives a 46" Blooming Mill in the South.
10. 10,000 hp twin double armature drive on a Blooming Mill in the Chicago District.



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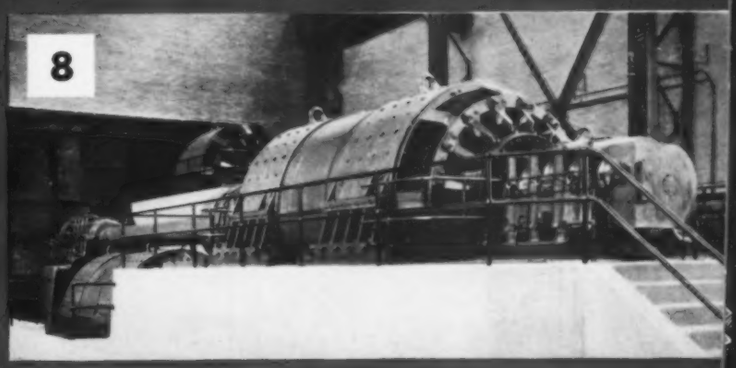
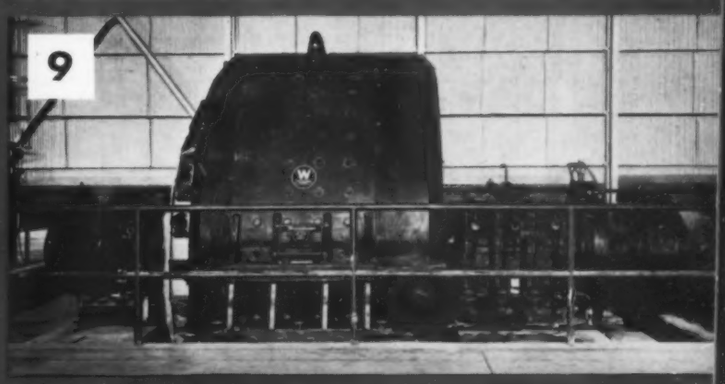
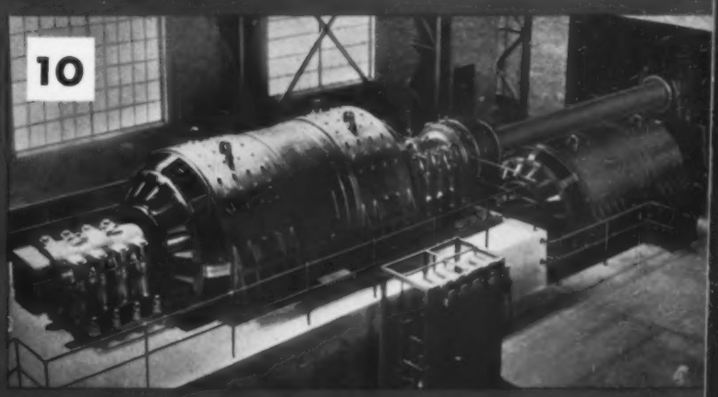
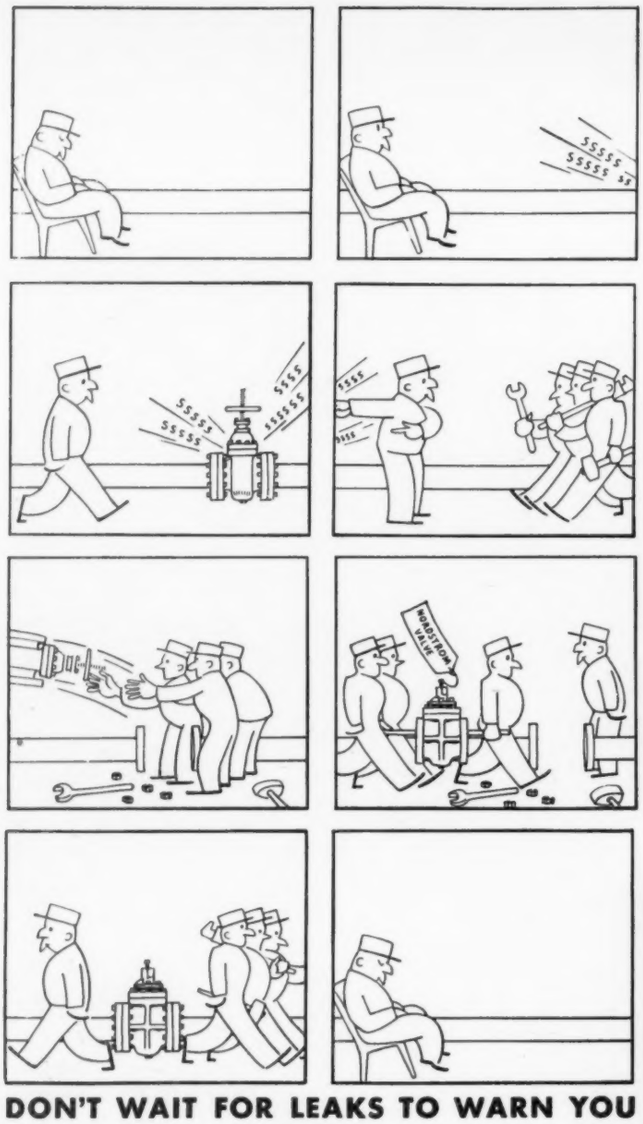






ELECTRICAL PARTNER OF THE STEEL INDUSTRY



DON'T WAIT FOR LEAKS TO WARN YOU

Leaking gas and vapor lines are a hazard that should not be tolerated. With Nordstrom Valves controlling your lines there's no further fear of leaks. Nor will these valves ever clog. The plug is lubricated. Hydraulic pressure, effected by turning a small lubricant screw applies pressure to the bottom of the plug to lift the latter slightly off its tapered seat if too hard to turn.

Leak-proof
Clog-proof
Corrosion-resistant
Erosion-resistant

EMCO-NORDSTROM TYPE

Ideal for handling hydro-carbon vapors, gases; for boiler and blow-off service, etc. Bulletin upon request.

NORDSTROM VALVES

MERCO NORDSTROM VALVE CO.

A Subsidiary of Pittsburgh Equitable Meter Co.
400 LEXINGTON AVENUE, PITTSBURGH, PENNA.

RIGHT NOW...

MORE VALUABLE THAN EVER...

DIXON'S TICONDEROGA FLAKE LUBRICATING GRAPHITE

With demand exceeding steel mill capacity, maintenance men rely, more than ever, on Dixon's Ticonderoga Flake Lubricating Graphite . . .

A pure, uniform lubricant unaffected by heat, pressure, solvents and moisture. Keeps lubricating long after other plain lubricants wash, burn, or squeeze out. Ideal for packings and coating gaskets . . .

Mixed with oils and greases, Dixon's Graphite impregnates wearing surfaces with a thin durable film that increases lubricant efficiency and prevents costly damage.

PARTICLE SIZE No. 1—large, lubricous flakes

PARTICLE SIZE No. 2—finely subdivided powdered flakes

DIXON'S No. 635—Minutely subdivided particle size for close tolerance applications.

DIXON'S MICROFYNE POWDERED GRAPHITE—microscopic particle subdivision for mixing with oils and greases. For dry lubrication of locks, small tools, etc., with Dixon's Graph-Air guns.

Write for Booklet No. C-18

DIXON'S ROLL NECK LUBRICATION SERVICE PROVIDES FACTS IN YOUR SAVINGS

Dixon's engineers can run a lubricant efficiency test in your mill without interrupting production. It will provide conclusive proof of actual savings possible with Dixon's Roll Neck Lubricants. No obligation. Write Dept. RN18.

GRAPHITE EXCELLENCE SINCE 1827

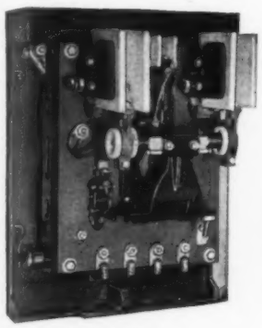
JOSEPH DIXON CRUCIBLE CO.
Jersey City, New Jersey

—646

OHIO

QUICK DROP MAGNET CONTROLLER

With arc suppressor and quick drop, automatic for any class of material.



Closed

Open for Inspection

Two main switches open circuit in series. Reverse and quick drop are automatic. Master contacts carry control circuits only.

The arc suppressor reduces the arc so it is not harmful or disagreeable. Contact tips are thus saved. Arc shields do not burn.

This controller makes possible 6 or more lifts per minute which is as fast operation as any we have ever observed in practice.

●

OHIO reliable MAGNETS

The OHIO Electric Mfg. Company
5907 Maurice Avenue
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Today American Industry must have efficient and dependable operating equipment. Over a quarter of a century's experience in the manufacture of Oil Immersed Motor Control equipment is your assurance of dependability in Rowan products.
ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Assigned to DEFENSE PRODUCTION

PERISCOPE TUBES AND GUN BARRELS AS WELL AS ROLLS ARE GROUND IN

FARREL ROLL GRINDERS

The design, productivity and operating precision of Farrel Heavy Duty Roll Grinders make them readily useful to some of the unusual needs of defense production.

The machine illustrated above is a standard 28″ roll grinder fitted to grind stainless steel tubes for submarine periscopes. These tubes are ground to tolerances of .002″ in concentricity (measured on the diameter) and .005″ in straightness for their full length. These are close tolerances for such long, slender, easily deflected tubes and their attainment in continuous daily operation is evidence of the utmost precision in the design and construction of Farrel Grinders.

Other Farrel Heavy Duty Roll Grinders are performing similar precision jobs, such as grinding the jacket fits on the barrels of 155 mm. guns.

Periscopes, gun barrels and similar cylindrical work, as well as rolls of any type—concave, convex or straight—can be ground with speed and accuracy in Farrel Heavy Duty Roll Grinders. Automatic and semi-automatic features, finger-tip control from the operator's station, and built-in accuracy facilitate operation and minimize dependence on the operator's skill. For all types of product to which it is adapted, on any materials, for either heavy roughing cuts or the finest finish, the Farrel Heavy Duty Roll Grinder gives positive control of accuracy to predetermined standards, with capacity for sustained high output.

Most of the capacity of the three Farrel-Birmingham plants is devoted to the production of machinery and equipment essential to the national defense program. Included in this defense production are Farrel-Sykes Gears and Drives for rolling mill service, of which a few typical units are illustrated at the right.

Double Reduction Gear Unit with Integral 44″ Pinion Stand for 40″ x 168″ Reversing Mill.

4000 HP Pinion Stand for Four-High Reversing Cold Strip Finishing Mill.

Farrel-Sykes Continuous Tooth Herringbone Gear for Rolling Mill Drive, 184.78″ outside diameter.

FARREL

FARREL-BIRMINGHAM COMPANY, Inc.

ANSONIA, CONN.

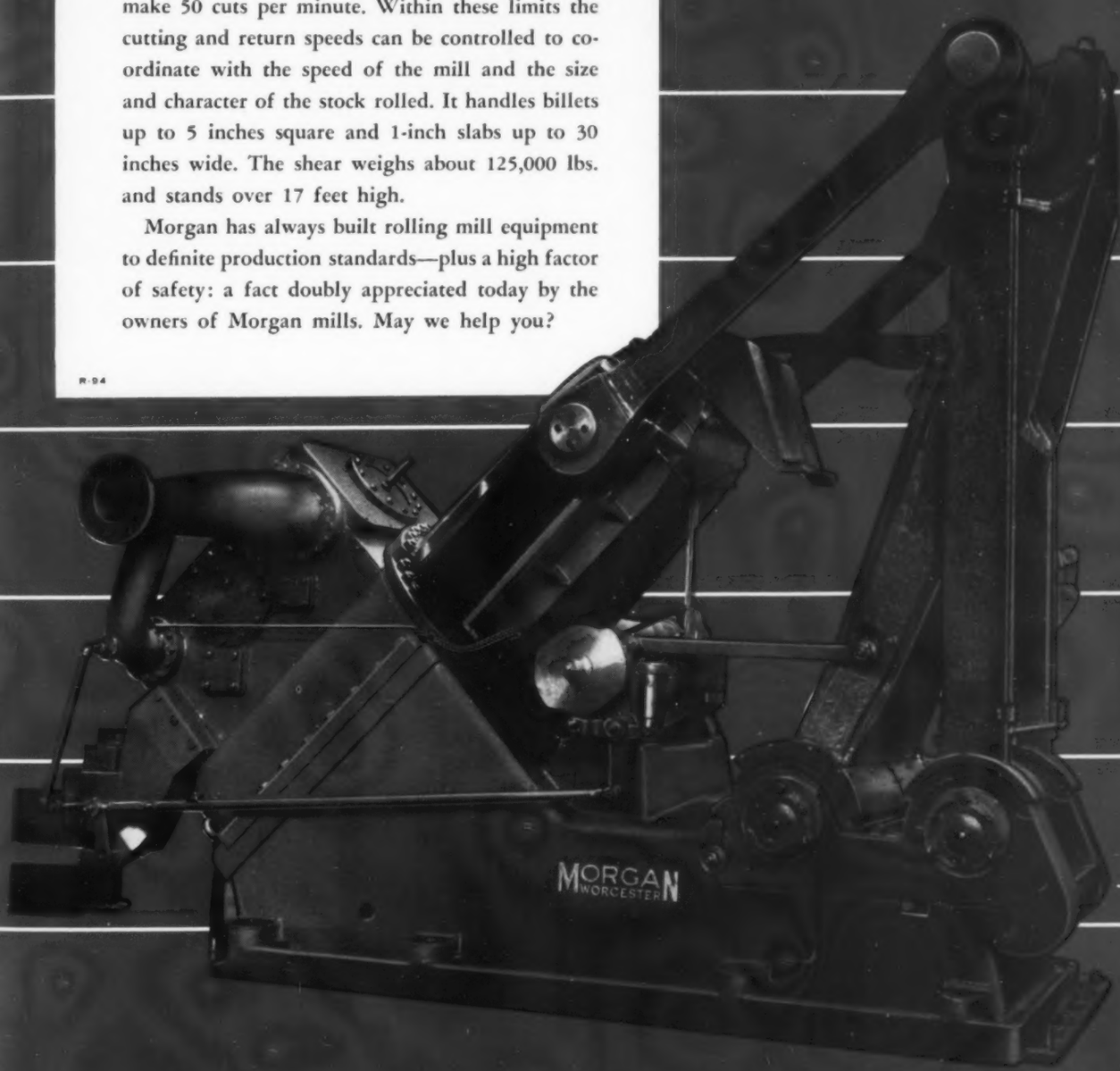
New York • Buffalo • Pittsburgh • Akron • Chicago • Los Angeles

. . . IT'S THE *Largest Flying Shear* IN THE WORLD

It has maximum speed of 900 F. P. M., and will make 50 cuts per minute. Within these limits the cutting and return speeds can be controlled to co-ordinate with the speed of the mill and the size and character of the stock rolled. It handles billets up to 5 inches square and 1-inch slabs up to 30 inches wide. The shear weighs about 125,000 lbs. and stands over 17 feet high.

Morgan has always built rolling mill equipment to definite production standards—plus a high factor of safety: a fact doubly appreciated today by the owners of Morgan mills. May we help you?

R-94

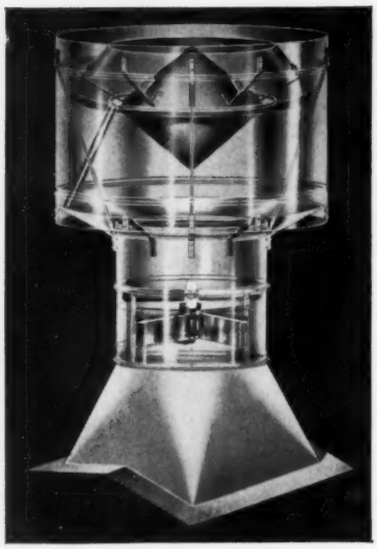


MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS

BURT

FREE-FLOW FAN

VENTILATORS



Produce Double-Quick Ventilation

Wherever you have the problem of exhausting a large volume of hot or fume-laden air rapidly from over a definite area, here Burt Free-Flow Fan Ventilators give the best performance. Their particular fitness for steel mill application has been proved many times. Efficiency is extraordinary, greatly exceeding that of gravity ventilators of the same size. Summer or winter, no matter what the wind direction or weather condition, the powerful exhaust action is always positive and uniform.

Burt Free-Flow Fan, Free-Flow Gravity and Monovent Continuous Ridge Ventilators present a range that meets all steel mill requirements. Detailed data, job references and engineering assistance will be gladly furnished.

THE BURT MFG. CO.

ROOF VENTILATORS • OIL FILTERS
EXHAUST HEADS

980 SOUTH HIGH STREET AKRON, OHIO

SEND FOR CATALOGS

Burt Engineers are glad to help on plans

Insure Long Life From Ball and Roller Bearings

Those you lose from faulty lubrication will be very hard to replace. Defense needs are resulting in a shortage of wanted sizes. Why take chances with bearings of machines vital to production?

NON-FLUID OIL safeguards bearing life by lubricating dependably. It protects bearings from pitting and corrosion, so guarantees long life and trouble-free operation. Recommendation by leading makers of ball and roller bearings proves it superior to grease.

Used successfully in leading iron and steel mills. Send for testing sample today—prepaid —NO CHARGE.

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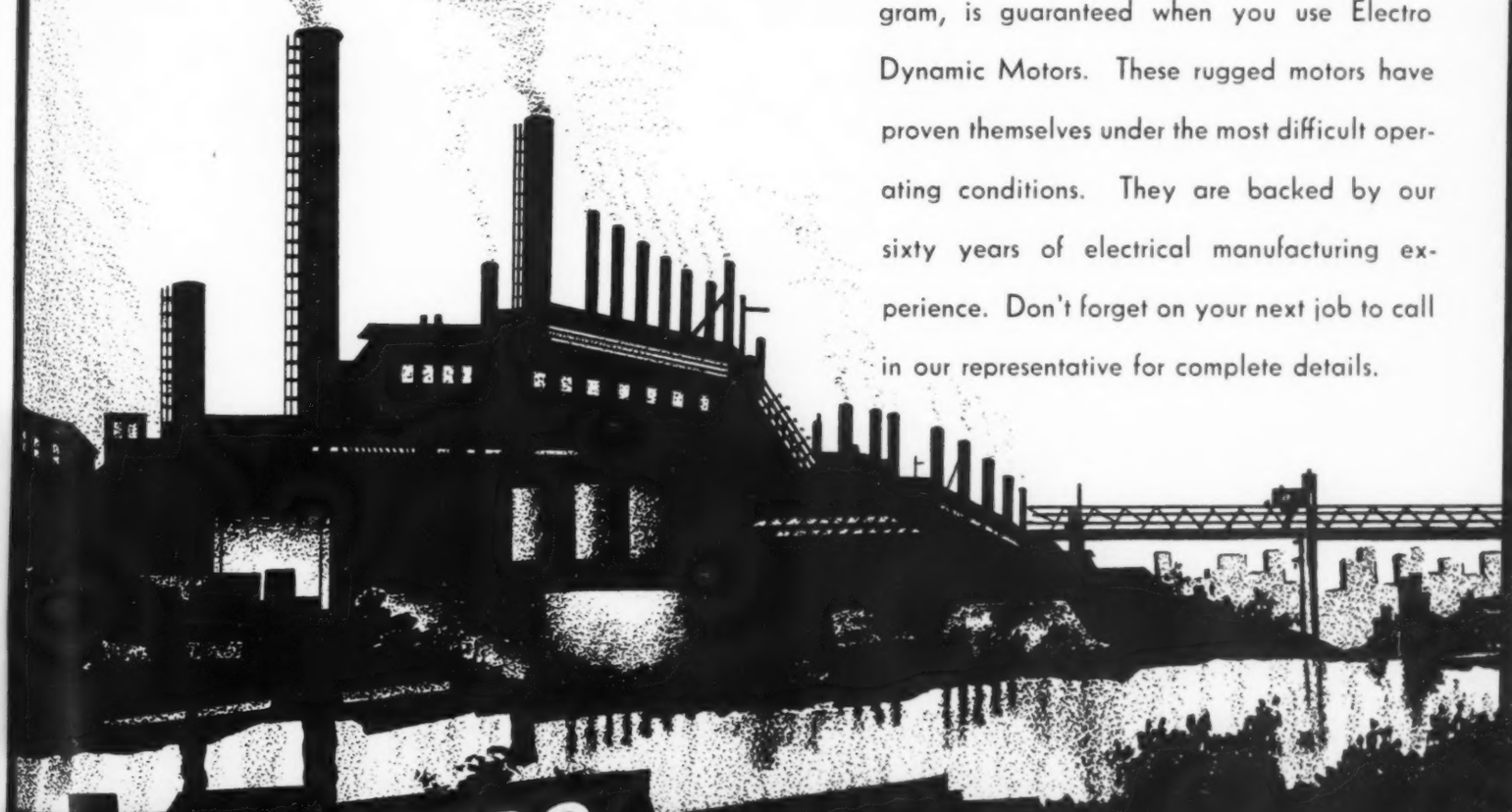
MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

PRODUCTION in STEEL

is the watch-word today

Continuous production in your steel plant, being so vital to the National Defense Program, is guaranteed when you use Electro Dynamic Motors. These rugged motors have proven themselves under the most difficult operating conditions. They are backed by our sixty years of electrical manufacturing experience. Don't forget on your next job to call in our representative for complete details.



ELECTRO DYNAMIC WORKS

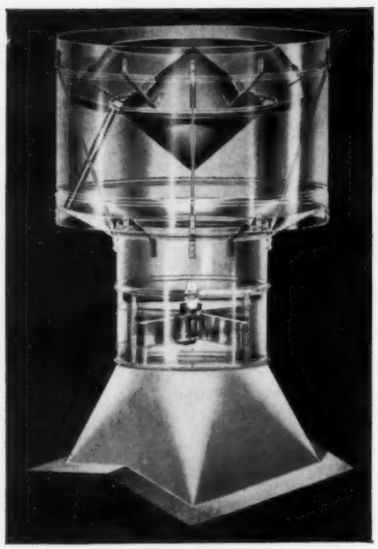
OF THE ELECTRIC BOAT COMPANY — BAYONNE, N. J.

PITTSBURGH OFFICE — 1907 INVESTMENT BUILDING

BURT

FREE-FLOW FAN

VENTILATORS



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Burt Engineers are glad to help on plans

Insure Long Life From Ball and Roller Bearings

Those you lose from faulty lubrication will be very hard to replace. Defense needs are resulting in a shortage of wanted sizes. Why take chances with bearings of machines vital to production?

NON-FLUID OIL safeguards bearing life by lubricating dependably. It protects bearings from pitting and corrosion, so guarantees long life and trouble-free operation. Recommendation by leading makers of ball and roller bearings proves it superior to grease.

Used successfully in leading iron and steel mills. Send for testing sample today—prepaid —NO CHARGE.

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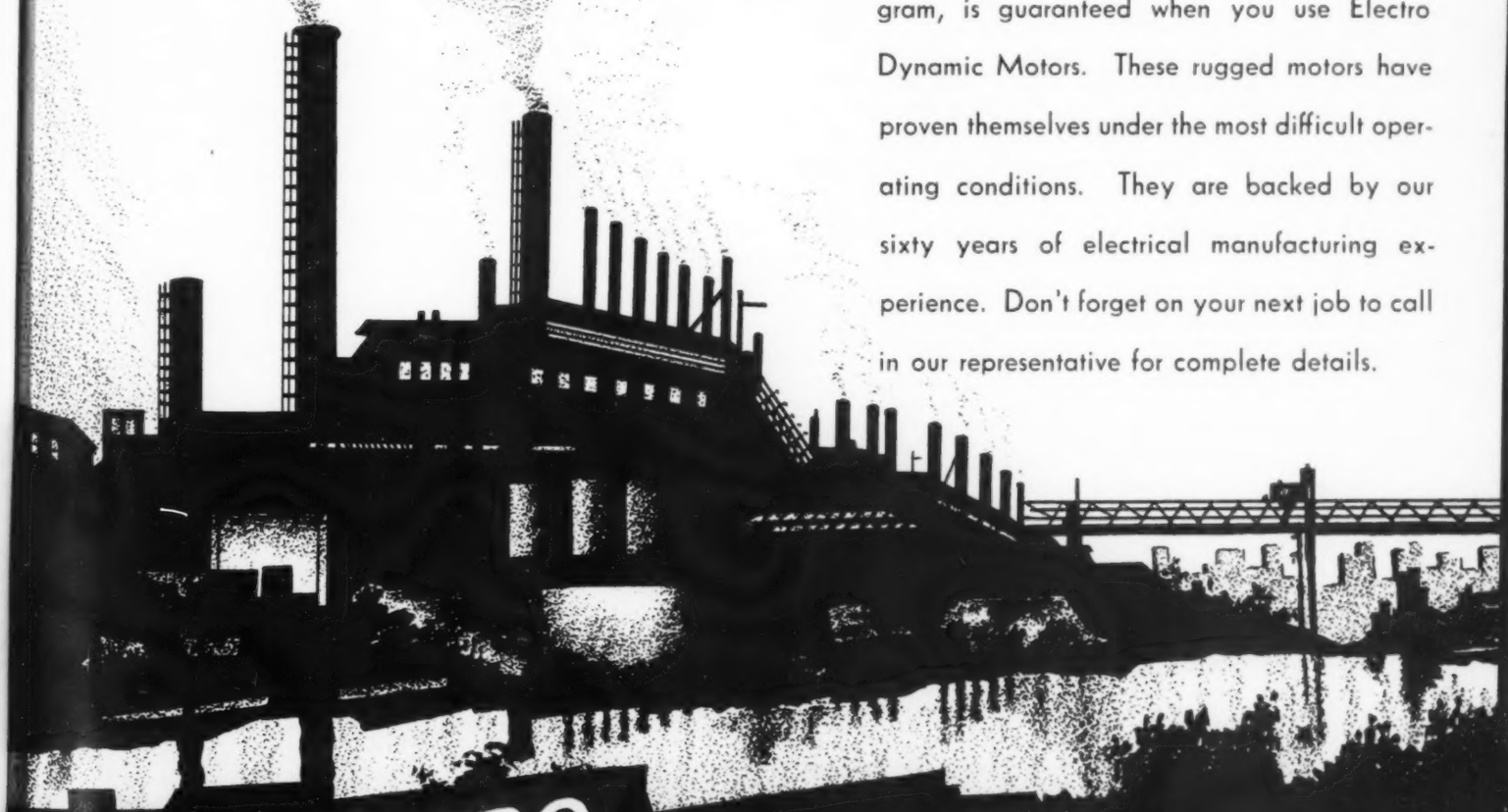
MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

PRODUCTION in STEEL
is the watch-word today

Continuous production in your steel plant, being so vital to the National Defense Program, is guaranteed when you use Electro Dynamic Motors. These rugged motors have proven themselves under the most difficult operating conditions. They are backed by our sixty years of electrical manufacturing experience. Don't forget on your next job to call in our representative for complete details.



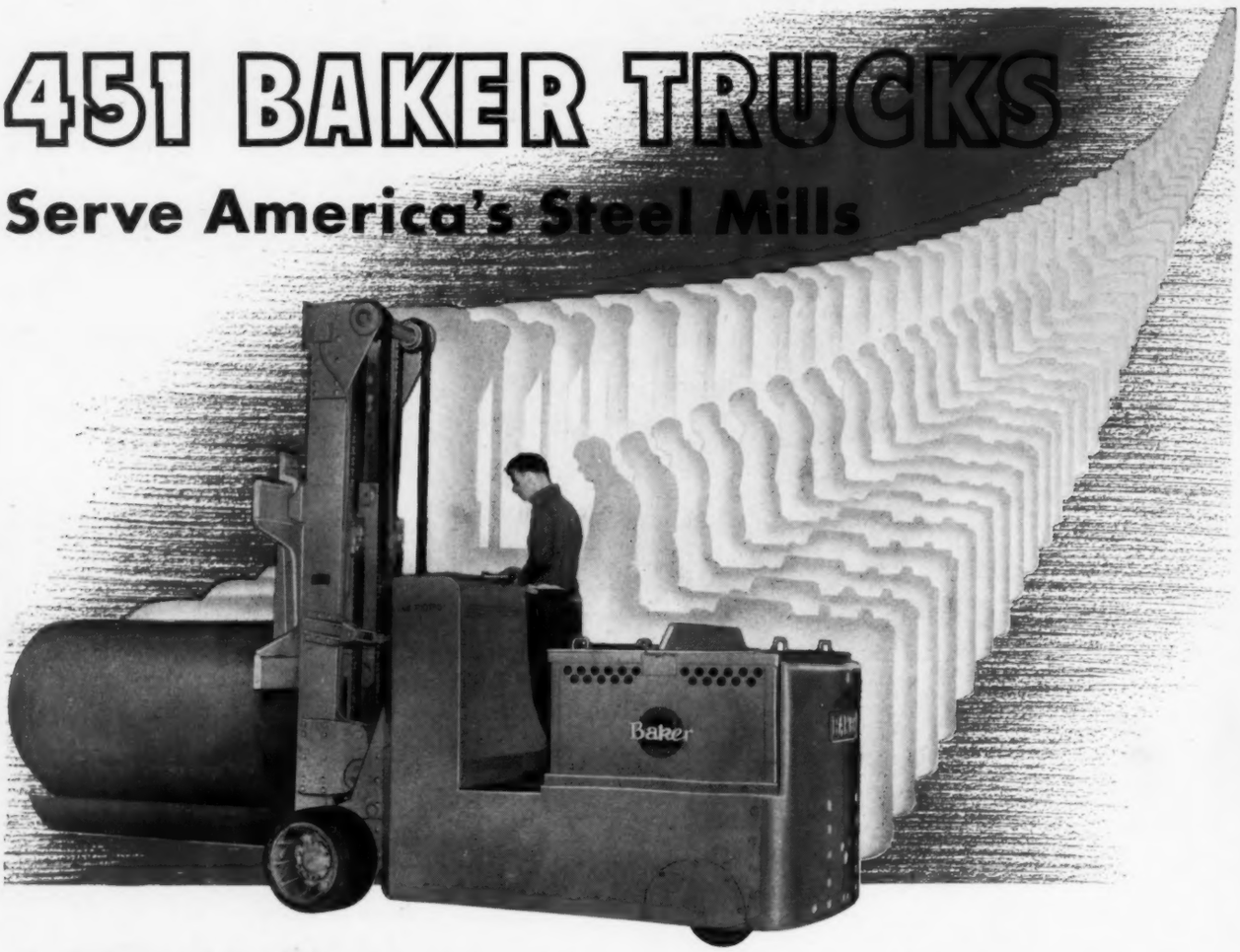
ELECTRO DYNAMIC WORKS

OF THE ELECTRIC BOAT COMPANY — BAYONNE, N. J.

PITTSBURGH OFFICE — 1207 INVESTMENT BUILDING

451 BAKER TRUCKS

Serve America's Steel Mills



Of 84 mills using Baker Trucks, 62 have bought 2 or more — 11 have bought 10 or more and 4 have bought more than 50!

● The men who make Steel know what they want when they buy industrial trucks. They prefer Baker Trucks because they know, among other things, how much high cost alloy steel goes into their construction. They know that the Baker Heavy Duty Truck has one of the strongest drive axles ever built into any industrial truck. They know, from personal experience, that Baker Trucks have the stamina that assures dependable performance and low maintenance under the gruelling conditions in their mills.

Because of the increased demands for Baker Trucks in Defense Production, we recommend that future requirements be anticipated now.

BAKER INDUSTRIAL TRUCK DIVISION
of the Baker-Raulang Company
2166 West 25th Street • Cleveland, Ohio

Baker has pioneered many improvements in Steel Handling

Cooperating with steel mill engineers, we are constantly developing and introducing new features to step up efficiency of steel handling. Outstanding Baker contributions are:

Ram Truck for handling coils
Center-Controlled Truck
Articulated Sheet Handler

●

Be sure to visit the Baker exhibit, booths 134-136, at the Iron and Steel Exposition in Cleveland, Sept. 23–25, 1941.

Trade mark Registered U. S. Pat. Off.

Baker INDUSTRIAL TRUCKS

in Canada: Railway and Power Engineering Corporation, Ltd.

now

you can get cast tooth mill table bevels with the accuracy of cut teeth and having our regular "Tool Steel" hardening.

Our exclusive Randupson process cement mold made from a cut tooth aluminum pattern brings you the benefit of smooth, evenly spaced teeth. Add to this our "Tool Steel" hardness and the result is 5 to 15 times the life of soft cut tooth bevels—and at the same price.

Hundreds of these gears on all types of tables have proven the above, and, in addition, show as much as 25 times the life of the old style cast tooth bevels.

You, too, can have savings like these. Give our "Tool Steel" gears your order to produce them.

THE TOOL STEEL GEAR & PINION COMPANY

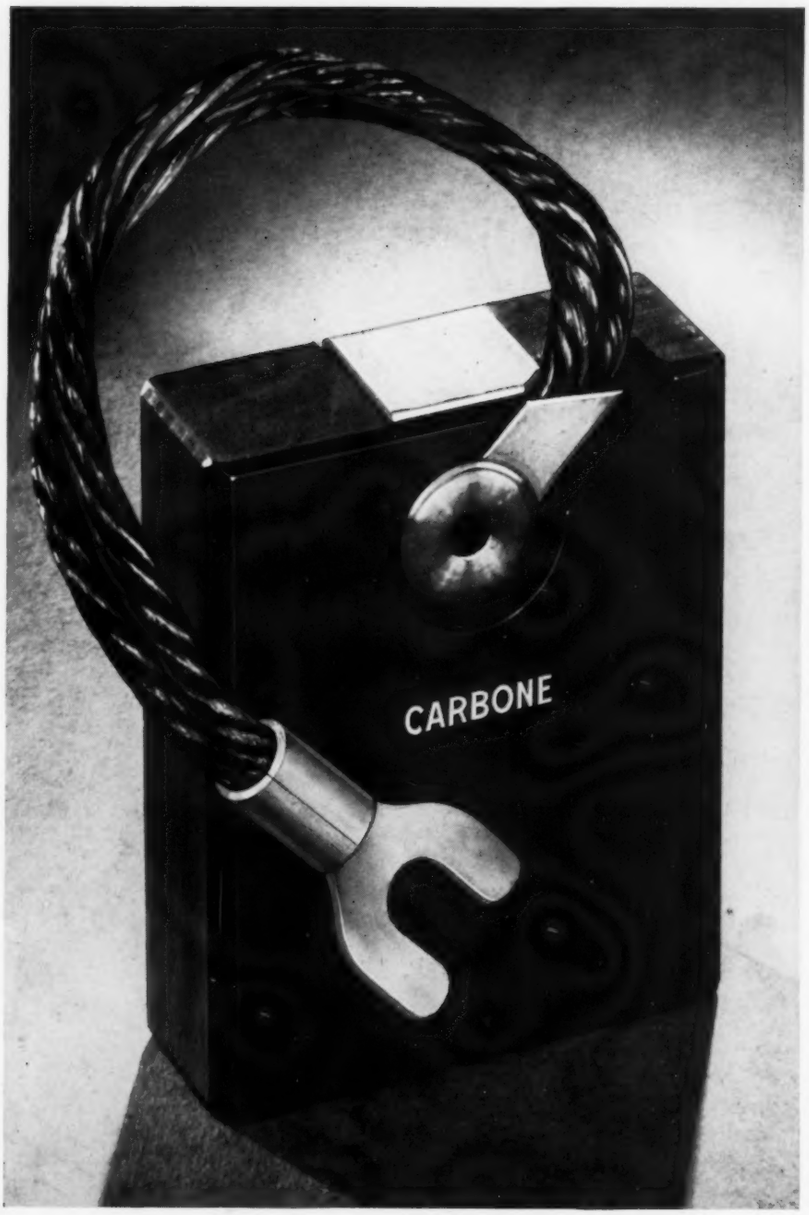
CINCINNATI, OHIO

DEPENDABLE

BRUSH SERVICE PROVED BY YEARS OF USE

Carbone Brushes—the choice of experienced operating men in mills all across the country—are delivering the uniformly reliable, efficient performance essential to today's need for dependable operation of electrical equipment.

Carbone Brushes, and Carbone engineering skill offer you exactly the right brush for the job—from the largest of heavy-duty mill motors to the smallest auxiliary—and the assurance of quality, uniformity, and efficiency in brush performance to keep electrical machinery on the job without trouble.



The Carbone Corporation

BOONTON, NEW JERSEY
NEW YORK, PITTSBURGH, CHICAGO,
SAN FRANCISCO

Iron and Steel Exposition
Space 17
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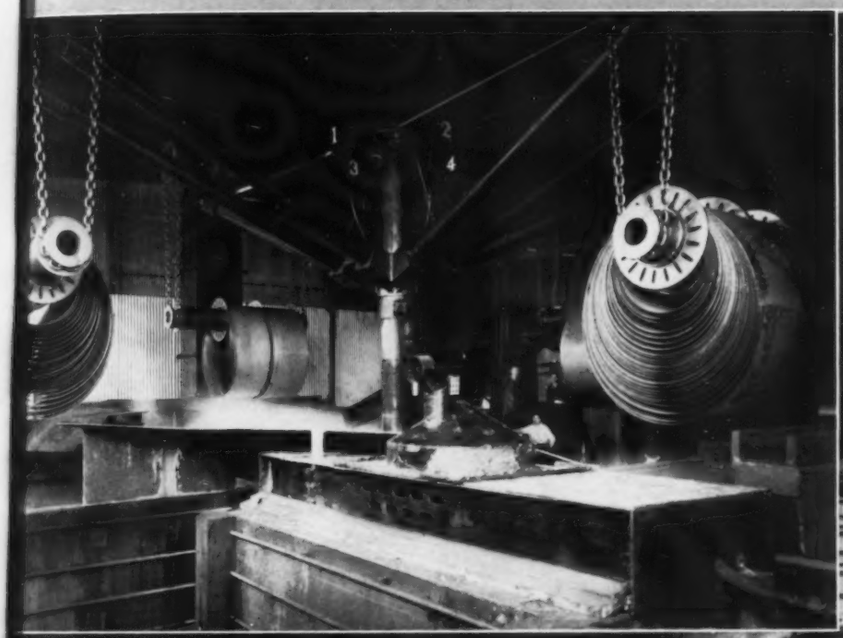
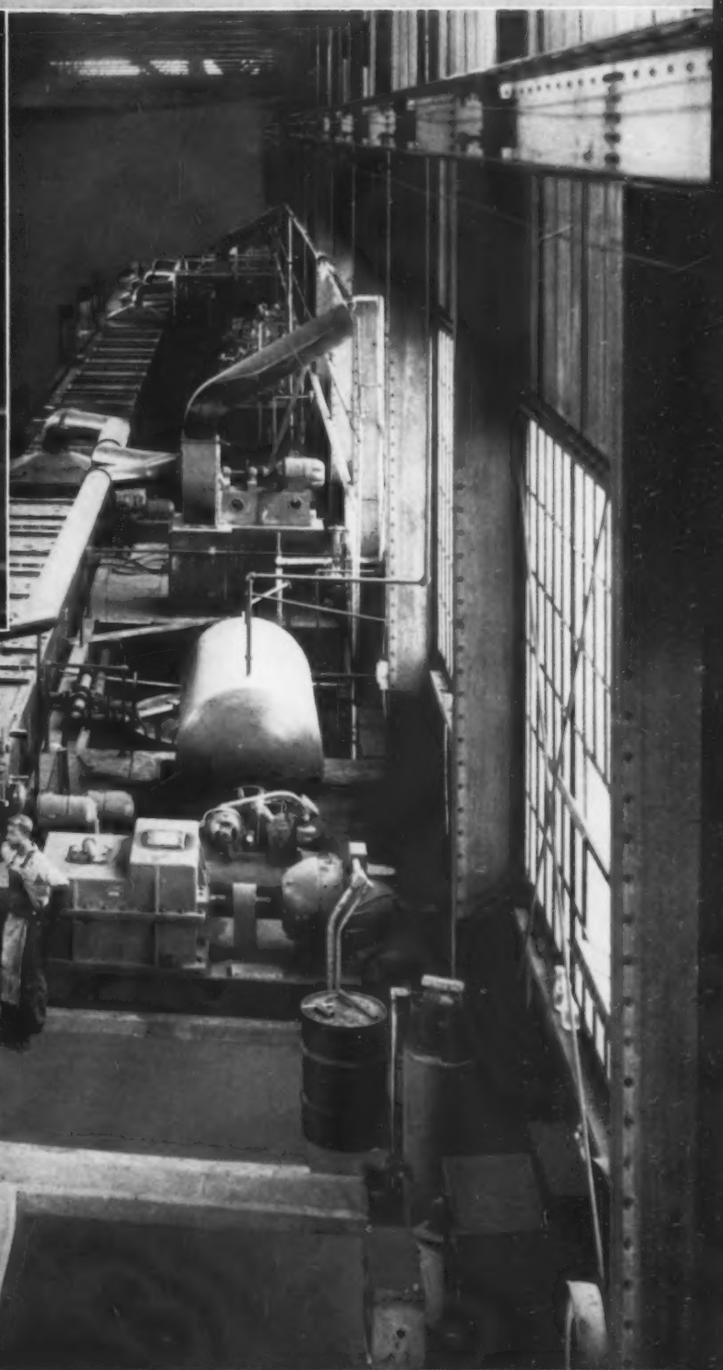
CARBONE *the world's first* **CARBON BRUSHES**

UNITED

STRIP PICKLERS

Rotary and Continuous Types





UNITED ENGINEERING *and* FOUNDRY COMPANY

Pittsburgh, Pennsylvania

DAVY AND UNITED ENGINEERING COMPANY, LTD., SHEFFIELD, ENGLAND · DOMINION ENGINEERING WORKS, LTD., MONTREAL, P. Q. · UNITED INTERNATIONAL, S. A. PARIS, FRANCE · SHIBAURA-UNITED ENGINEERING CO., TOKYO, JAPAN

Photograph by Bud Scott

HE WANTS TO GO TO CLEVELAND WITH HIS "OLD MAN"

But dad's going to be pretty busy listening to technical papers by leading steel mill authorities, inspecting the latest equipment and design in mill machinery, and visiting the other fellow's plant to study how he handles his problems.

He's not the only little fellow who is going to be crying, because lots of "dads" are going to be in Cleveland for the Iron and Steel Engineers Convention and Exposition. These are strenuous times and all the "dads" from the steel plants know that they are going to hear and see things that will help them turn out more steel quicker, cheaper, and better.

Dad's going to get a lot out of this coming meeting. He realizes the vital importance steel production is to the nation's welfare and isn't going to shirk his duty by staying away from a convention that will be so helpful and stimulating to him in his daily work.

37th ANNUAL CONVENTION
AND IRON AND STEEL EXPOSITION

Association of Iron and Steel Engineers

CLEVELAND PUBLIC AUDITORIUM
September 23-24-25

★ ★ ★ ★